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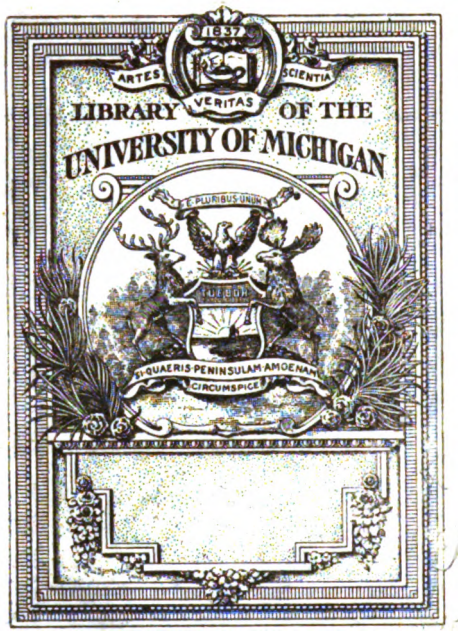

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SUPPLEMENT TO "THE ELECTRICAL ENGINEER," JUNE 29, 1894.

THE

ELECTRICAL ENGINEER.

A WEEKLY JOURNAL OF ELECTRICAL ENGINEERING,

WITH WHICH IS INCORPORATED

"ELECTRIC LIGHT."

VOL. XIII. (NEW SERIES.)

FROM JANUARY 5, 1894, TO JUNE 29, 1894.

LONDON:

Printed and Published for the Proprietors by BIGGS & Co., at "THE ELECTRICAL ENGINEER" Offices, 139-140, Salisbury-court, Fleet-street, E.C.

1894.

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THE

ELECTRICAL ENGINEER.

No. 1, Vol. XIII. LONDON, JANUARY 5, 1894. PRICE 3D.

NOTES.

English-Made Carbons.—It is noteworthy that electric light carbons are now being made in England.

Gainsborough.—The suite of rooms erected for the purposes of art and science classes are lighted throughout with the electric light.

The Shipley Tramways.—The Board of Trade has held an enquiry as to the application of the Shipley Local Board to acquire the tramways.

A New Cable.—The Eastern Extension Telegraph Company is reported to be on the point of laying a cable between Hong-Kong, Labuan, and Singapore.

Patents.—During the past year applications for the grant of British patents for inventions were more numerous than in any previous year, the number being 25,102.

Lighting of Baths.—The Newington Vestry, who propose to erect baths and wash-houses in Manor-place, Walworth, intend to spend £500 on lighting the buildings by electricity.

Central London Railway.—The extensions of time desired by the Central London Railway Company are respectively two and three years beyond the time originally granted by Parliament.

Those Tickers Again.—It is stated that the Stock Exchange Committee has confirmed the recommendation of the sub-committee, that the use of tape prices should be under the committee's control.

Lighting of St. Paul's.—The authorities of St. Paul's Cathedral, it is stated, have definitely decided to introduce the electric light. In Easter week an appeal will be made to the citizens to defray the expense.

The "Proper Position" of Gas.—Lord Ernest Hamilton states that "gas as a lighting agent is being gradually superseded by electricity, and will ultimately be relegated to its proper position as a simple heating agent."

Australia-New Caledonia Cable.—It is stated that during the first three weeks' operation of this cable only 45 telegrams were sent through it, each way, at 1f. 10c. per word. A correspondent submits that this can hardly be regarded as a lucrative business.

The Institution.—An ordinary general meeting of the Institution of Electrical Engineers will take place at 25, Great George-street, Westminster, on Thursday next, the 11th inst., when the president, Mr. Alexander Siemens, M.I.C.E., will deliver his inaugural address.

The "Medical Battory Company," Limited.—At the Marlborough-street Police Court, on Wednesday, Mr. Hannay resumed the hearing of the charges of conspiracy to defraud brought against Mr. Harness, Mr. McCully, and Mr. Hollier. Further evidence was adduced and the hearing again adjourned.

Dust Collectors.—A Boston firm suggests that early every morning large cars should be sent over all the lines of the electric railways, and that garbage and refuse gathered along the way should be shoveled into them. Large watering cars would follow these dust collectors.

"Indian Engineers' Diary."—The publishers of the *Indian Engineer* have forwarded us a copy of the "Indian Engineers' Diary and Reference Book for 1894." A lot of useful information is given in the book, which is specially intended for those connected with engineering in India.

Personal.—Mr. Haydn T. Harrison has resigned his position of manager of the testing and standardising department of the Electrical Standardising, Testing, and Training Institution, Faraday House, Charing Cross-road, to enter into partnership with Mr. N. F. Nalder to carry on the business of electrical engineers.

New Year Honours.—Mr. W. H. Preece, F.R.S., engineer-in-chief to the General Post Office, and Mr. J. Norman Lockyer, F.R.S., professor of astronomy in the Royal College of Science, have been appointed Knight Commanders of the Bath. Mr. R. Hunter, the solicitor to the Post Office, has been created a knight.

"Calvert's Mechanics' Almanack."—We have received a copy of "Calvert's Mechanics' Almanack and Workshop Companion for 1894." The almanack, which has now reached its twenty-first year of publication, contains practical and technical information useful to artisan and handicrafts and those generally engaged in mechanical, engineering, building, and constructive trades. It published by Messrs. J. Heywood, of Manchester and London.

Cylindrical Copper Conductor Resistance for Alternating Currents.—With reference to the article published in our last issue, page 613, M. Hospitalier writes making some corrections. He states that in the nineteenth line of the second column the words "frequency in seconds" should read "frequency in periods per second." In the fourteenth line of the same column the words "product diameter by frequency" should read "product of the square of diameter by frequency."

Traction at Hull.—The Electric Lighting Committee of the Corporation have had presented to them a report on the application of electricity as a motive power for the tramways. It was decided to appoint a sub-committee to watch the employment of electricity in this direction, and a resolution was passed requesting the town clerk to insert a clause in any agreement with a new tramway company, binding such company to use the current supplied by the Corporation for operating the cars.

Another Gas Explosion.—Judging from the explosions which have recently occurred, the gas in Glasgow seems to be very partial to the electric lighting mains. We recorded one explosion last week, and another has since taken place, this being last Friday. It appears that three men were

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working at a manhole in West George-street repairing one of the mains at a point where there was an accumulation of gas, and a light being used an explosion resulted. Two of the men working at the time are reported to have been severely injured about the head and hands, and the third man was slightly burned.

Charing Cross-Hampstead Railway.— The Charing Cross, Euston, and Hampstead Railway Company, which was incorporated last year with powers to construct an underground electric railway from Charing Cross to Hampstead, with a branch line to Euston, have deposited a Bill for next session of Parliament, under which the company seek for powers to acquire, in addition to that authorised last year, important properties situated in the Strand, Villiers-street, Buckingham-street, Oxford-street, High-street, Camden-road, Kentish Town-road, Melton-street, Drummond-street, and Cardington-street.

Bequest.—The sum of £600 per annum has been bequeathed to the trustees of Mason College, Birmingham, by the late Mr. Aubrey Bowen, of Melbourne. The testator stipulates that the trustees shall, within a reasonable time, undertake to apply the sum in founding six scholarships of £100 a year each in connection with the college, to be called respectively the First, Second, and Third Bowen Scholarships, for the promotion of the study of metallurgy, and civil, mechanical, and electrical engineering; and the First, Second, and Third Priestley Scholarships, for the promotion of the study of chemistry.

A New Electrical Vehicle.—A new electrically-propelled carriage, according to *Industries*, is being introduced by M. Paul Pouchain, of Armentières, France. The carriage will carry six persons. The electrical energy is supplied by a battery of 54 Dujardin accumulators. The motor is of the Rechniewski type, with an output of 2,000 watts. It is fixed in the centre of the vehicle, and transmits its power by chain gearing to the driving wheel. According to the inventor, the total weight of the carriage and equipment is about $1\frac{1}{3}$ tons. One charge of the accumulators is sufficient for a journey of about 44 miles at a speed of 10 miles per hour.

Electric Traction at Budapest.—It is announced that the company which owns all the tramways in Budapest, having altogether a length of about 56 miles, has resolved to adopt electricity as the motive power over the entire system. The conversion of the system, it is computed, will take three years to complete. The total cost of the change is estimated at £1,000,000. Whilst the Government and Municipality there are vying with each other in such improvements in the means of transport, the authorities in Vienna, remarks a correspondent, treat that important interest with strange indifference. There are whole districts, especially in the suburbs of this capital, which are still without the convenience of a tramway, or have only partial and very insufficient accommodation of that kind. The populous outer suburbs of Vienna were incorporated with the city three years ago, yet up to the present moment nothing has been done to unite them actually by means of tramways.

Electric Traction in Dublin.—The Dublin Southern Tramways Company have obtained sanction to introduce electricity as a motive power, and this means, according to a local paper, that passengers will be carried to Dalkey for sixpence in 40 or 50 minutes. The additional capital required to carry out the scheme for running the cars by electricity is estimated at from £100,000 to £150,000, and as the project is a local one, and calculated to benefit a large section of the population of the city and suburbs, it is looked forward to with hopeful anticipations. Some time since a bold proposal was made, which, now that so much has been said about a railway for Clontarf, is well worth considering. The plan was to construct a cable line from Howth to Dollymount, and then to have electric cars to the city. The cars, descending from an elevated point at Howth, would by gravity derive sufficient motion to reach Dollymount and to pull the cars from Dollymount up to the point of starting at Howth. This would shorten the journey very considerably between the city and this splendid outlet.

The Battersea Polytechnic.—The doors of this polytechnic were to be thrown open for the reception of students yesterday evening. The formal inauguration of the institute by the Prince of Wales will take place in the course of this or next month. Many of the classes will prepare for the examinations of the Science and Art Department and the City and Guilds of London Institute, and special courses have been arranged applicable to various trades and industries, the institute offering certain scholarships and prizes open only to students attending such courses. The institute contains nearly 100 classrooms and other apartments, chief among which are well-equipped laboratories for chemistry, physics, mechanics, and electrical engineering. In addition, there are well-fitted workshops for woodwork, ironwork, brickwork, and masonry, and the engineers' workshop contains examples of all ordinary machines and tools, and a small smithy. A steam-engine of 100 h.p., a gas-engine of 20 h.p., and two dynamos, with accumulators and other appliances, are also available for teaching purposes.

The Hermite Process at Worthing.—As mentioned in our issue of the 22nd ult., the Hermite system of treating sewage with electrolysed sea-water is about to be experimented with at Worthing. A yard in West-street, near the sea, has been placed at the disposal of the Corporation for this purpose. Two alternative schemes have been sketched out for the treatment of the borough sewage should these tests work satisfactorily. The first is to convey sea-water into the new main sewer at the west end of the town, and the other is the supply of the water through mains to every house in the town in lieu of fresh water *viâ* the flushing-cisterns. For the purposes of the trial temporary closets will be erected in the West-street yard, here also the plant and machinery will be placed and the sewage at once dealt with. M. Hermite has undertaken to carry out the trials, which will extend for a month, for £200. In addition to the temporary closets to be erected, it is proposed to disconnect four houses from the sewer, and the discharge, after being conducted to receiving-tanks, will be treated in full view.

Liverpool Overhead Electric Railway.—It is satisfactory to note that this railway, which was started for traffic in March last, has now been taken over from the contractors, the Electric Construction Company, Limited. The contractors were under an obligation to work the line for two years from the date of opening at a fixed rate of 4d. per train mile, but the working has been so satisfactory that the railway company have decided to take over the line as from the 1st inst., and the electrical company are relieved from all responsibility of the working and maintenance. The railway company contemplate putting into execution the powers they have of creating four new stations at the north end of the line. Two of the new stations will be opposite the Trafalgar and Nelson Docks respectively, a third at Sandhills-lane, and the fourth at Langton-street. The company are also proceeding with the extension of the line to Seaforth, where a very fine station is to be be built, of the Pierhead type, but completely roofed in. Several improved carriages are to be constructed of the most modern type.

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Long-Distance Telephony.—Some time ago an arrangement was come to between the Postmaster-General and the National Telephone Company whereby Dundee subscribers to the company's system could have the advantage of telephonic communication with the company's subscribers in Belfast and Dublin *vid* the Post Office trunk wires between Belfast and Glasgow. Several firms in Glasgow have already availed themselves of the arrangement, whilst one firm in Dundee has followed the example. The Post Office charge for a three minutes' use of the trunk wire between Glasgow and Belfast is 3s. Thus, should a subscriber in Dundee desire to communicate with Belfast he may do so on payment of 3s. 9d., the additional 9d. being the charge for the use of the company's trunk wire between Dundee and Glasgow. Dublin may be communicated with on payment of an extra shilling, while communication may also be established with several other towns in the North-East of Ireland. With a view of still further improving the service, the telephone company have decided upon entirely reconstructing the switchboards in their Dundee exchange.

Society of Arts.—The ordinary meetings will recommence on Wednesday evening, the 17th inst., when Mr. A. P. Laurie will read a paper on "White-Lead Substitutes." The arrangements for the succeeding Wednesdays are as follows: January 24, "American Carriages," by Mr. G. Herbert Thrupp; January 31, "Californian Wines," by Mr. Charles P. Oldham; February 7, "Reproduction of Colours by Photography," by Captain Abney, C.B., F.R.S.; February 14, "The St. Pancras Electric Light Installation," by Mr. Henry Robinson, M.I.C.E.; February 21, "Electric Signalling Without Wires," by Mr. W. H. Preece, C.B., F.R.S. The next course of Cantor lectures will be delivered on Monday evenings, January 22, 29, and February 5, 12, by Prof. Frank Clowes, D.Sc., the subject being "The Detection and Measurement of Inflammable Gas and Vapour in the Air." Mr. Hugh Stannus, F.R.I.B.A., will give a course of Cantor lectures on "The Decorative Treatment of Traditional Foliage" on February 19, 26, and March 5, 12. Further Cantor lectures will be delivered by Captain Abney on "Photometry," and by Mr. H. C. Jenkins on "Typewriting Machines."

Electric Lamps on the District Railway.—In our last issue appeared a note on train-lighting, in which it was stated that "The intention was that the light should only fall on the book or newspaper of the person who dropped in the penny; but the apparatus is said to be so placed that when the compartment is full the light neither benefits the person sitting next the window nor his next neighbour, but falls between the two." Mr. J. Tourtel, managing engineer to the Railway Automatic Electric Light Syndicate, Limited, of 37, Walbrook, E.C., has written to correct this statement. He says: "This is quite incorrect, as our reflectors being movable, a man is able to direct the light upon his paper in any desired position. Some people prefer to operate by a method of their own, totally regardless of directions: some press the knob without inserting a coin; some insert the coin and omit to press; while some, who succeed in obtaining a light, omit to adjust it to suit their convenience, and occasionally, through the Press, they unconsciously proclaim their deficiency in intelligence. Fortunately, however, such people are rare."

Electrical Communication with Lightships.—The necessity for a method of communication between lightships and the shore is becoming manifest in the United States, as has been the case in this country. Included in the recent estimates submitted to Congress is £10,000 for establishing electrical communication in this direction. Appended to the estimate is a note stating that: "The House of Representatives Committee on International and Foreign Commerce on December 6, 1892, asked the views of the Treasury Department as to the Bill appropriating £10,000 to provide communication from lightships and outlying lighthouses to the shore. Favourable reply was made on December 8, 1892. Since then the Lighthouse Board has experimented, and is now satisfied that it can establish electric communication between lightships and shore. It is proposed to commence with an important lightship quite near shore, then take a more important one more distant, and then, if need be, another still further away, and thus acquire by successive efforts the experience needed to successfully lay an electric cable to connect with the shore the most distant and important lightship—that on the New South Shoals, some 30 miles off Nantucket, Mass."

Prize for an Essay on Wind Power.—The Netherland Society for the Promotion of Industry, the secretary of which is Mr. F. W. van Eeden, of Haarlem, Holland, offers its prize for 1894 for papers indicating the method of obtaining energy by means of windmills, to accumulate this energy electrically, and to transmit it or make it portable. An answer to the following questions is more particularly desired: (1) What is the average energy a common windmill is able to produce, per day of 24 hours, in combination with an electric accumulator; what would be the installation most suitable to this effect, and what would be the cost of one horse-power hour? (2) Is it possible, from an economical point of view, to apply the new aerial motors on an extensive scale for the accumulation and the utilisation of this energy? If so, what mechanical appliances would be required for this purpose? The project of a supposed application of the system by which a factory is provided with light and power, is wanted as an illustration. The drawings belonging to the answers must be made on white paper on a scale of ¼in. to the foot. The prize comprises the gold medal of the society and the sum of £30. The papers are to be sent before July 1, with the author's name in a closed envelope, to Mr. F. W. van Eeden, of above-mentioned address.

Railway Rates.—Sir Albert K. Rollit presided at a meeting of the London Chamber of Commerce on Wednesday, when the report of the Select Committee on Railway Rates was discussed. The Chairman said the report was not all that the traders might have wished, but it contained much which, through Parliament, might be made beneficial and useful. It certainly was material for legislation, and their chief object should now be to press as rapidly as possible before the House of Commons the recommendations of the committee. Mr. Edgar Howell moved, "That this meeting, having considered the report of the Select Committee on Railway Rates, expresses satisfaction with the recognition, to a great extent, of the contentions of traders therein contained, and of the recommendations made, so far as they recognise the necessity of providing means for a speedy determination of what is and what is not a reasonable actual rate." The resolution was seconded by Mr. S. B. Boulton, supported by Mr. Burnie, M.P., and carried unanimously. On the motion of Mr. Thomas Blackwell, seconded by Mr. Rosenfeld, it was decided to recommend traders to communicate without delay to the Board of Trade, through the London Chamber of Commerce, the amount of their claims against the railway companies, whether in respect of deductions made from railway accounts or charges actually paid.

A Handsome Electric Light Column.—Recently the huge wooden casing in front of Wanamaker's, in Philadelphia, was taken down, and there stood revealed a

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handsome column of incandescent bulbs, with broad spiral stripes, each of a different colour—white, blue, purple, orange, green, yellow, and crimson predominating. The column is about 25ft. high, and from it extend four long arms lined with rows of glass bulbs of different colours, two of the arms in the side aisles terminating in 25 bulbs each, and two in revolving balls of 266 bulbs each, all handsomely coloured. At intervals of a few seconds, each stripe flashes with light, one brilliant colour swiftly following another until the top of the column is reached, when the varying light is diffused along each of the arms until the two large bulbs are reached, where the flashing continues until all the colours are shown. Meanwhile the two large balls are kept revolving, and flash continuously with varying lights and colours. The whole affair, whose effect is very pretty, is ingeniously managed from a switchboard in the basement under the column. As the lights change from one colour to another they go out completely, leaving no lingering glow in the carbons to spoil the effect, as would be the case were it not that this has been guarded against by a current of air being ingeniously injected automatically by the machine. The arrangement was a part of the famous electrical display at the World's Fair.

Electro-Tanning.—In a recent issue we mentioned that Mr. L. A. Groth had gone to Orbe, Switzerland, to establish his system of tanning in Mr. Rod's tannery there. The place intended for the new tannery is being obtained by blasting away the rocks facing the River Orbe, and this work was commenced last July. The first part of the buildings is estimated to be finished at the end of this month, when the tanning, we are informed, will commence with 300 hides per week, whilst the whole tannery, when finished, is estimated for a turn-out of 1,000 hides per week. The machinery for finishing the tanned hides into the various kinds of leather has already been ordered. The motive power required will be obtained from a waterfall of about 3,000 h.p., situated nearly two miles distant. There are installed two turbines, each of 300 h.p., acting upon dynamos from which the power is electrically transmitted into the town of Orbe, partly for lighting, which commenced on the 1st inst., and partly to be used as motive power for the large flour mill and tannery, both belonging to Mr. Rod. The electric railway from Orbe to Chavarnay railway station is also driven by the same power. The quality of the leather tanned by the Groth process is shown by Prof. Unwin's tests, the last one, dated October 26, 1893, being as follows: "Marked; Leather tanned in five weeks by Groth's system, Orbe, Switzerland, October 20, 1893, Jules Rod. Dimensions, 3·85in. wide by 0·2in. thick and 16in. long. Maximum load, 1·795 tons. Breaking stress, 2·3 tons per square inch of section, or 1,044lb. per inch of width. It stretched permanently 6 per cent. in 10in. The leather is rather above the average strength of good leather belting."

Repairing Edison Lamps is an Infringement.—The United States Circuit Court of Massachusetts has granted an injunction against the Davis Electrical Works, of Springfield, Mass., restraining the latter from repairing lamps under the Edison patent by substituting a new filament. The Court states that the process of repairing consists in first breaking off the tip of the glass bulb of the lamp and reaming out a hole about ½in. in diameter. The broken filament is then removed. The new filament, having its ends cemented into platinum sleeves, is then inserted into the glass chamber, the sleeves being pushed down over the two platinum leading-in wires and compressed upon them. A tube of glass made into the shape of a funnel is heated and placed over the hole in the lamp chamber. This tube is fused into the open end of the bulb, which brings it into the condition of the ordinary lamp bulb just prior to exhaustion. The air is then exhausted and the bulb sealed. It is evident, the Court decides, that this operation covers many of the constructive features of the ordinary lamp, whose claim consists of four elements: a carbon filament, a receiver made entirely of glass, conductors passing through the glass, and a receiver from which the air is exhausted. The Court decides that it is apparent that the defendants by substituting a new filament, making over the glass receiver, and exhausting the air from such receiver, produce a lamp in which all the elements but one (the leading-in wires) of the patented combination are used either in a new or reconstructed form. The lamp thus produced is substantially a new lamp, and its voltage may be higher or lower than the old one. From the very nature of the Edison invention, the Court does not see how the glass bulb can be opened and a new filament inserted without making essentially a new lamp.

Signalling Between Trains in Motion.—Some time ago we referred to a system of automatic railway signalling by electricity invented by Mr. Martin Perls, and it was mentioned that this system was about to be tried on some of the military lines in Germany. The trials took place on the 23rd of October last, and a report upon them has been read before the Verein für Eisenbahnkunde by Herr Bormann. The apparatus consists of a battery carried by each locomotive and connected, by means of metallic brushes, with a series of conductors laid parallel to the metals. The circuits are so contrived that two trains travelling upon the same metals, whether in the same or opposite directions, are warned of each other's position by the ringing of a bell on each locomotive, while, at the same time, the two drivers are brought into telephonic communication. The same thing occurs if one of the trains be stationary, so that drivers receive notice of any breakdown upon the line in front of them. The breaking away of a carriage or carriages from the rear of a train is also notified both to the driver and to the station which the train has last passed through; and the distances at which all these warnings are given and received can be varied in such a manner as to provide either long or short "blocks" according to the requirements of the traffic. The experiments described by Herr Bormann were conducted on the military line, 4·34 miles in length, between Mahlow and Marienfelde; and he sums up the results by saying that the apparatus has fully answered all expectations. A train entering a station was warned of an obstacle on the line. Two locomotives approaching each other on the same track were warned. Two trains proceeding in the same direction, the second at greater speed than the first, received warning. Lastly, a train which was entering Mahlow Station received notice that points were in a wrong position. In all these cases the notice was given in ample time to prevent danger, and to render a collision impossible.

The Cost of Electricity on the Canals.—Mr. E. T. Birdsall, in the columns of the New York *Electrical Engineer*, deals with this subject. He submits that from the editorial published in that journal of December 6th, "it would seem that the state engineer, Mr. Martin Schenck, does not take the same view of the problem of propelling canal boats with electricity that the enthusiasts at the trial did. Having gone over the possibilities of this matter some three years ago somewhat thoroughly, I am inclined to endorse his view. At the time mentioned I controlled a water power situated in the Mohawk Valley, only half a mile from the canal and about one-third of the distance from one of its termini. This power has a minimum of 5,000 h.p. at all seasons of the year, and can be developed at a

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minimum of outlay, yet we could not figure out a saving to the canal boatmen by the use of electric motors in place of the present engines. The enemy of all power transmission schemes is cheap coal, and in this case coal at 2·50dol. and 3·00dol. per ton gave the enterprise its death-blow. I grant that the size of this plant would have been miscroscopic compared with the Niagara power plant, but until reliable figures as to the cost of the power per horse-power at the Falls, and the cost of erection and maintenance of the trolley line on the canal are given, I shall continue to be doubtful as to the commercial success of the plan. I do not question that boats can be propelled by electricity delivered from a pole line, or that they can lessen the time of transit, but the question is, will it pay a divident on the investment? This is the whole problem. Again, is the automobile canal boat the best solution of the problem? I think not. This granted, we have either the locomotive on the towpath or a similar motor placed overhead. The mechanical difficulties of both the latter methods multiply rapidly as we proceed to work out the details of the system, and while I cannot yet see daylight through the problem, I think that either of these plans will give a much lower cost per ton-mile than the one tried. If it is suggested that electric tugs would be a solution of Mr. Schenck's objections, there again comes the question, Would not steam-tugs do the work cheaper? Small compound condensing engines do not use much fuel, and the interest on a pole line the length of the canal will buy a large amount of coal. Unfortunately I did not preserve the data and figures that I made on the cost of electric towing at the time mentioned, as I was certain it could not be made a commercial success at that time. While high pressures and multiphase motors may help the matter some day, yet the difference to be overcome is so great that in the absence of more reliable information and data, I think it will be well to restrain our enthusiasm until we have something more tangible to enthuse over."

Advice to Young Electrical Engineers. — A brief but interesting report of an interview with Mr. L. S. M. Pyke is contained in the December issue of the *University College School Magazine*. The interviewer, "C. L. T. G.," paid a visit to the works in New Tothill-street, first to see and learn what he could about Mr. Pyke's researches, then to find out what the latter thought of the future of high-tension work, and to obtain some advice for those who were thinking of taking up electrical engineering as a profession. "C. L. T. G." was shown over the works, and in reply to a question regarding alternators, Mr. Pyke said: "I have here an alternating-current dynamo whose beauty lies in having but one moving part, and the whole is extremely strong and rigid, and possesses no moving conductors. A large block of wrought iron almost cylindrical, 15in. in diameter and 12in. deep, has a groove turned in it, leaving the centre and a thick outside rim. This is wound so that one pole is north and the other south. Laminated iron projections and bobbins then concentrate the magnetic force in radial lines across the open space. Through the centre of the block a hole is bored which serves as a bearing for the shaft which carries the driving pulley on one side and on the other, iron bars in the shape of an L turned over so that the end turns in and revolves between the coils mentioned and induces alternating currents in them. This machine would light 120 8-c.p. incandescent lamps at the safe and ordinary pressure of 100 volts." Transformers next came under notice, after which the interviewer asked for some advice to the young engineer. To this Mr. Pyke said: "On leaving school I went direct to the works of George Wailes and Co., Euston-road, for I hold that the electrical engineer should have a thorough knowledge of the ordinary mechanical and constructive work—turning, filing, fitting, erecting, etc. It was there that I began my first work in the high-tension line. We had some of Ferranti's earliest alternators to construct, and in the trouble and woe surrounding the first few dozens of these machines it was necessarily possible to gain much experience, at the same time reading and learning all I could in my spare time about the then almost unexplored field which is now my speciality. When I had served my time at Wailes's, I started for myself with my partner, Mr. Harris, in building small dynamos, working a great deal with and for Sir David Salomons, until now our work has so grown that we pay about £50 a week in wages. Electrical engineering is as overcrowded as all other professions, and the man who wishes to make his way must be a hard worker in the first place, and if he has not capital at his back, he must either have a speciality, or must be a genius or something like it."

An Improved Method of Traction Desired.— The Metropolitan Traction Company sent a letter to the New York Board of Railroad Commissioners in November last, offering a prize of £10,000 for the invention of a system of street railway propulsion superior to the cable and the trolley. In this letter the officers of the company say: "On streets where the lines are straight and the business is heavy the cable system is the most economical yet invented. For general use in a city, winding about through the streets following the routes of travel which the public wish to pursue, it is impracticable. You require straight routes for cable roads. We have in addition to the lines upon which the cable will be laid over 80 miles of street railroads now operated with horses, al below the Central Park. It is to these lines in particular that we now desire to direct your attention. Up to the present time the only system whose practicability has been demonstrated is the overhead trolley. We are well aware, however, that its application in the streets of New York would not meet with the approval of the community. What we most desire now is to hasten the development and perfection of a better system. We therefore submit the following proposition: First, we will set aside the sum of 50,000dol. to be awarded as a prize to any person who shall, before March 1, 1894, submit to your honourable Board an actual working system of motive power for street railway cars demonstrated to be superior or equal to the overhead trolley. Second, the qualities necessary to meet this requirement shall be left to your decision; but with the present state of the art, a system to win the award must necessarily approximate the trolley as a standard of economy in operation, but should be without the features objectionable to the public that are in it. Third, we shall exact no rights in the invention in return for the 50,000dol., and shall have nothing whatever to do with the making of the award further than to pay any expenses which your honourable Board may deem it necessary or wise to incur, either in the employment of experts, the giving of hearings, or the conduct of experiments—this in order that no effort may be spared to achieve the desired result." In answer to this proposition, Mr. S. H. Beardsley, on behalf of the Railroad Commissioners, sent a letter to President John D. Crimmins undertaking to co-operate with the company with certain limitations. Mr. John D. Crimmins states that the offer of the company was made for the best interests both of the company and of the city. He was sure the overhead trolley would never be introduced into New York. The general idea was to encourage the invention of some sort of underground trolley system which would be free from the disadvantage of liability to kill horses and men in the streets above it.

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A PLEASURABLE NEW YEAR'S VISIT AND DISCOURSE.

Immediately after entering the office of a celebrated firm in Queen Victoria-street a few days ago, I heard a muffled voice exclaim, "A happy New Year to you," and on looking round I beheld a full-sized figure of a jolly Jack Tar standing at "salute." Feeling sure that the good wish emanated from the wax model, I replied, "Same to you old fellow, and to all associated with electric science," and thus commenced an amusing, interesting, and instructive visit. The figure contained a loud-speaking telephone receiver and a well-designed carbon transmitter in communication with similar apparatus in an adjoining room. My next surprise was equally amusing, for after surveying the beautiful display of electric fittings which adorned the showroom, I caught sight of an excellent piano, and was irresistibly tempted to try its musical powers; but judge my surprise when about half-way through that pretty song "You Promised Me," the instrument struck up on its own accord, "Jack's Come Home Again"! The contrast was comical indeed, and as the automatic system (a punctured cardboard band rotated in a drawer under the keyboard by an electric motor) totally eclipsed my feeble attempt at playing, I at once retired to a back seat, pressed an electric cigar-lighter to my "weed," and then listened to some inspiriting tunes as they were evolved by the wily "skeleton in the cupboard."

Frying-pan? Yes, certainly. Just put it on that stand for two minutes; now touch the bottom. I did so, and quickly withdrew my overheated fingers to avoid unpleasant frizzling. "Where is the flame?" I asked. No flame; simply an electric current passing through a wire in the stand. A steak was soon afterwards hissing in the place where my now reddened finger tips had been, and its juicy quality, combined with scrupulous cleanliness, was enough to satisfy a prince and promote the beginning of a life of pleasure for the new year. What with electric kettles, saucepans, tureens, flatirons, curling-tongs, and other heating apparatus, to say nothing of the latest electric novelty (which I was jokingly assured would make a good impression on any uncovered back), a "bacon-marker." I stood amazed at the various contrivances actuated by electricity. Lamps of numerous shapes, ranging in size from a pea (as now used for gun-sighters in the navy) to globes 6in. in diameter capable of yielding 600 c.p.; night-lights for watch stands; arc lamps, some of which were inverted to project the light on the ceiling; all kinds of appliances for theatrical effects; step-up transformers from 100 to 2,000 volts for advertising in Geissler tubes; electric clocks; a variety of models, such as workshops, toy motors, railways, and other essential objects for instructing the young aspirants to electrical engineering pursuits; telephones and shop fittings galore; even electric horse-clippers, helped one and all to make the uninitiated mind more confounded. When we seriously reflect on the advancement of science and its practical applications during the reign of our Most Gracious Queen it seems almost incredible that her subjects could have so fully developed their researches within such a short period. The foregoing details form but a very minute portion of one branch of science, and although much can now be done with electricity and magnetism, yet much more remains to be done. Electricity can produce sound, light, and heat, and, conversely, the three latter agents can generate electricity; but notwithstanding these facts we cannot instantaneously "see by electricity." Some unknown genius may yet, however, accomplish this much-desired end. Following the grand law of conservation of energy we may reason—though not quite true—that an electric lamp reproduces sunlight which illuminated the earth's surface thousands of years ago. For example, trees absorbed heat from the sun and many years afterwards became coal; coal when raised to its proper igniting temperature again liberates the occluded heat; a small proportion of the heat if set free in the fire-box of a steam-boiler enters the water, and then the steam; the steam works an engine and thereby converts a portion of its heat energy into mechanical energy; the engine drives a dynamo, and thus produces electricity; the electricity is suitably conveyed to an electric lamp, where its easy flow is strongly resisted by a carbon filament; this obstruction regenerates heat at a high temperature, and, in consequence, light is again made visible. An old adage says "Wonders will never cease"; but I think the climax will be attained if the bold prophesy comes true—namely, that because electricity can dissolve copper at one end of a wire and precipitate the metal from a blue vitriol solution at the other end of the wire, it may happen, in the distant future, that physicists will be able to decompose a man in London, and by aid of the same current through the Atlantic cable build him up again in New York! P.

ON CERTAIN DEVICES TO UTILISE INDUCTIVE ACTION IN THE CONSTRUCTION OF LONG SUBMARINE CABLES.

BY DESMOND G. FITZ-GERALD.

Considerable interest has been excited, both across the Channel and the other side of the Atlantic, by the statement that the great scientific firm of Siemens and Halske have devised a method whereby they can obtain on a line of which the length is expressed by 3 the same rate of speed in signalling as would ordinarily be obtained on a line of which the length is expressed by 2. In other words, admitting, in accordance with what is known as the law of the inverse square of the distance, that the increase of length from 2 to 3 would ordinarily reduce the speed of signalling to 44·4 per cent. of its original value, they increase the speed of signalling through the given cable just *two and a quarter times*.

If this be correct—and, in the absence of any disclaimer on the part of the eminent firm above mentioned, we may assume it to be the fact—a great step has been made in submarine telegraphy, a splendid achievement in science would appear to have been practically carried into effect. And we may here expect to find consummate skill both in the application of abstract scientific principles and in the mechanical construction of the apparatus, whereby the progress has been realised. In many points of detail—each one essential to success—novelty and originality will no doubt be conspicuous. But, in justice to probably more than one patient worker in the past, we must point out that the device which has been adopted by Messrs. Siemens and Halske, and which is not claimed as new in theory, was not only suggested but was experimentally elaborated to some extent—though not conclusively demonstrated—some 14 years ago. In one particular case, we know that experiments were carried out under many difficulties and discouragements, and that a very high authority was reported to have stated in regard to them that "if the experimenter had been an electrician, he would have known that no increase of speed could be obtained by such means."

The device in question is simply to divide the cable into two or more sections, and at each division to connect the severed portions to earth respectively through the two wires of an induction coil, these two wires being of equal length and resistance, and alternately primary and secondary according to the direction of the transmission.

Supposing the cable to be divided into two, the speed of signalling through each section is theoretically increased fourfold. Assuming the through signals to be strictly consecutive, the signalling capacity of the whole cable would thus be doubled. But in practice no doubt the signals would to some extent overlap—that is to say, signal 2 would be passing through section 1 *before* signal 1 had passed through station 2. On the other hand, the effect of what used to be called electromagnetic resistance, or what is now termed inductance, has to be considered and allowed for. And it should be borne in mind that the electro-dynamic induction effects which are in this case utilised tend to disappear when the inducing current is insufficiently *sudden—i.e.*, when the variable period which precedes its normal passage is unduly prolonged.

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Analogous to the above device, but containing in far less degree the elements of practicability, is the plan of utilising—or attempting to utilise—electrostatic instead of electro-dynamic induction by connecting the severed portions of the conductor respectively to the two coatings of a condenser insulated from earth. Here the difficulty is encountered of obtaining, by means of two copper bands sufficiently insulated from each other, a condenser of sufficiently considerable capacity as compared with that of the cable itself, which is about one-third of a microfarad per knot. The *inducteous* charge—that of the same sign as the inducing or *inductric* charge—is, so to speak, *lost* in the inductive circuit of the cable, becoming too much reduced in potential to be capable of producing a signal.

The question as to how far the law of the inverse squares of the distances becomes in its effect modified by certain conditions of practice, is—as well as the law itself—of great interest to practical electricians. We look forward to a period when such questions may be studied upon an artificial cable similar to that devised by the late C. F. Varley, but free from the economical makeshifts which had the effect of bringing its artificiality *en evidence*. Such an apparatus would be of national importance, and would probably need to be provided by the nation.

HIGH-SPEED ELECTRIC RAILWAYS.

BY FRANK B. LEA.

When one comes to think of it, the idea of enlarging upon the principles—not to say details—involved in a high-speed electric railway is rather absurd, if not visionary, seeing that the number of lines operated in this country by electric power at any kind of a speed may be reckoned on one's fingers. However, there has been some considerable "talk" upon the subject during the past year; and no less an authority on electric traction than Dr. Edward Hopkinson appears to have regarded the matter as of sufficient importance to merit discussion before distinguished and learned audiences. His treatment of the subject has, of course, been purely general; the absence of practical facts makes it almost impossible to enter in any way upon details, and until railway speeds of 120, 150, or 200 miles per hour can be attained in some fashion, even experimentally or by models, no one ought to predicate the conditions or laws under which such results are to be reached.

Take, for instance, the question of atmospheric resistance, which is dealt with by Dr. Hopkinson in a theoretical manner to show that with a train 200ft. long and travelling at a speed of 200 miles per hour, the energy required to overcome such air resistance alone would be as much as 1,700 h.p. A train of this length may be considered, from the analogy of rolling-stock upon the Liverpool Overhead Railway, to be made up of four cars, each about 50ft. long, and weighing perhaps 60 tons inclusive of motors. A speed of 200 miles per hour is equivalent to one of 17,600ft. per minute, so that on the level, and allowing a traction coefficient of only 10lb. per ton, the power required to maintain this speed with such a train $= \frac{250 \times 10 \times 17{,}600}{33{,}000}$, or over 1,300 h.p. Added to the 1,700 h.p. which Dr. Hopkinson estimates as being necessary to overcome the air resistance, then we have a total of 3,000 h.p. This is equivalent to a total horizontal effort of 5,625lb.; and deducting from this the amount due to traction resistance—viz., 2,500lb.—there remain 3,125lb. as the value of the total air resistance. If this be considered to act wholly in a direction parallel to the line of travel with close-coupled cars having an end area equal to that, say, of the Liverpool Overhead Railway cars—viz., 8ft. 9in. by 11ft. (to rail-level), or, approximately, 96 square feet—the air resistance per square foot of area works out very nearly to 33lb., an extremely high allowance, to judge from the results obtained by Mr. O. T. Crosby a year or two ago, when experimenting upon high speeds and the values of air-resistance coefficients.

"Atmospheric resistance," says Mr. Crosby, "at 150 miles per hour would be taken (in the proposed case) at 15lb. per square foot of cross-section, a wedge or parabolic-shaped head being employed for the car. *This value is 50 per cent. in excess of that indicated by our experiments.* (The italics are mine.—F. B. L.)

Of course, one cannot say that either of these two conflicting *estimates* (for they are nothing more) is correct or incorrect. Actual working will alone show the laws that govern high-speed transit, not only with regard to the atmospheric resistance, but also as to a fair allowance to be made for tonnage coefficient of traction. Of course, the permanent way at such velocities would be of very special character and design; and therefore every care might be taken to reduce the rolling resistance. But even then the allowance of 10lb. per ton might prove too little, although it is well within the mark for speeds of 70 or 80 miles per hour on a first-class track of ordinary construction.

This point brings me to at least one other subject in this connection which is of interest at the moment to those who watch the developments of high-speed transit. I refer to the proposals that have been made with a view to attaining velocities of 150 miles an hour and over, on an elevated single-rail track of the type devised by M. Lartigue, and already used in one or two instances for short local lines at slow speeds.

There seems not to be the least doubt that any such velocities as those mentioned will only be attained by changing altogether the type of roadway adopted; at any rate, the cost of easing curves and grades on a surface line of modern form, in order to run trains at double or treble the present speeds, would be quite prohibitive. In this respect, therefore, the Lartigue system may prove to be the forerunner of a permanent roadway just suitable to high speeds. Personally, I think it goes in the right direction by reducing to some extent the bearing points between trains and rails.

With the powers involved by such high speeds, and the concentration, as it were, of destructive energy along one line, it becomes, however, a matter of supreme importance to increase the strength of the permanent way. I should feel inclined to doubt whether any ordinary girder work on a foundation which is more or less shallow would serve the purpose. The strains in a superstructure of this kind would be enormous, and would necessitate special designs—*e.g.*, each line being adapted for service in one direction only.

This is hardly the place or time to attempt a detailed criticism, however; later on, when actual work is attempted, the particulars may come up for review. At present, therefore, it is enough to say that the scheme, as enunciated, requires considerable modification before it could be put into practice. Take, for instance, the advantage claimed for it of utilising the present railway embankments instead of buying fresh land or rights of way at enormous cost. Surely it is not thought seriously that embankments are to be found along the whole course of our railways! Probably they do not constitute anything like 30 per cent. of the total length of line, and even then would be found to change from embankment to cutting, and *vice versâ*, in a space short enough to prove rather embarrassing to the levels of the single-track system. However, this is a small detail: it is only mentioned to show the necessity of a little wholesome revision on certain points. Generally speaking, the system has decidedly interesting and useful features.

STANDARD CELLS.

BY E. C. RIMINGTON.

It is, I think, not generally known that a Clark standard cell is perfectly unharmed by being circuited through resistances of the order of 1,000 ohms. Some years ago the writer made a long series of experiments with various patterns of this cell, employing a variety of different pastes, etc., and, among others, tried the rate of recovery from polarisation due to circuiting. Two identical cells, made according to Lord Rayleigh's instructions, in test-tubes about ¾in. in diameter, were used, the ratio between their E.M.F.'s compared, and was found to be 1·00027. The

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cell of higher E.M.F. was then circuited through 1,000 ohms for 17 minutes. It internal resistance was afterwards measured by Mance's method, and found to be about 130 ohms, so that the total resistance of the circuit was 1,130 ohms, and the current given about 1·27 milliamperes. The circuit was then broken, and its rate of recovery noted by comparing its E.M.F. at definite intervals with that of the other cell. The second column in the subjoined table gives the ratio of the E.M.F. of the cell that has been circuited to that of the uncircuited one.

Time reckoned from instant of breaking circuit.	Ratio of E.M.F.'s
2½ minutes	·9999
4 ,,	1·00007
9 ,,	1·00020
31 ,,	1·00021
1 hour 20 ,,	1·00027

So that in one hour twenty minutes it has completely recovered, while in nine minutes its recovery is enough for all practical purposes.

In the above cell the surface of mercury would be about ·44 square inch; as a matter of fact it was less than this, as a glass tube containing the platinum wire dipped into it, and this would reduce it to about ·4 square inch. This gives a current density of about 3·2 milliamperes per square inch of mercury surface. A larger cell would, of course, have a greater surface of mercury, and would bear circuiting through a lower resistance for the same amount of polarisation.

THE EXPENSE OF RUNNING ELECTRICAL ENGINEERING BUSINESSES.

BY SYDNEY F. WALKER.

Probably few electrical engineers, except those who have been in business for a number of years, appreciate how very heavily all electrical engineering work is handicapped by the dead expenses involved in carrying on the work. The remark is true of all engineering businesses, but particularly of electrical engineering. Even the rapid advances of which all electrical engineers are so proud, add considerably to the cost of working. Some new improvement is made, and not only patterns and drawings, but perhaps a lot of finished work becomes dead stock, of the value of old metal. When, too, as is constantly happening, one firm works out an improvement in some part of their apparatus, every other firm making the same class of apparatus must follow suit, no matter at what cost, or be left out in the cold when orders are given out.

It must be borne in mind too, by those who think electrical engineering businesses so many veritable Eldorados, returning enormous profits upon small outlay, that the proprietors of an electrical engineering business have to make good, not only their own slips, but those of all their employés, and often those of the employés of other firms. To be successful, you must follow your work, see it kept right, no matter what it costs or into whose hands it goes. If you do not, any breakdown is attributed, not to the apparatus being improperly looked after, but to the apparatus itself being improperly made. And unfortunately, too, electrical engineers are very much like women, in that they are rarely able to see any good in each other's work. Few electrical engineers, if called in to repair the work of another firm, can resist the temptation to condemn the rival firm's work. And so all these little things cost money, and a good deal of it. And besides all these, as every electrical engineer of experience knows, every now and then something turns up, some new development of the laws of the science that had not occurred to anyone before, that often appears at first sight to be contrary to those laws, but which always lead to one result—additional expense, more or less heavy, for the manufacturer or contractor.

And the above are in addition to the regular expenses of all properly conducted businesses. Keeping accounts so that you may know what you are owed, and what you owe, and what your expenses really are, is an important and often a very heavy item in proportion to the business done. Even the correspondence of electrical engineers in business is heavier and more costly than that of other businesses. The thing is new, and buyers often require to be very sure of their ground. Misunderstandings are more likely to arise over work that is quite new to one of the parties concerned than where both are familiar with the principal details. And this necessitates the treasuring up of every letter that one has written or received for years after.

Securing orders is also, if one may judge by what one sees in other lines of business, a far more expensive matter in electrical engineering than elsewhere. Electrical engineers themselves are, perhaps, to blame for a large part of this. No sooner is it known that an order is in the market than the representatives of several firms rush for it, each bent on belittling all his rivals. Tenders, too, are a constant source of expense, and the writer believes affect electrical engineers more severely than other business. People do not scruple, apparently, on the plea of asking for a tender, to put several firms to heavy expense often without the slightest intention of employing any of them; sometimes even merely with a view to obtaining information.

All of these things, and many others, cost money, and, unfortunately, the sum of them, when added up, bears a very heavy proportion to the amount of business done. With limited companies the proportion is usually even higher.

The writer's object in penning this article is to endeavour to deter those who are engaged in electrical engineering businesses from the stupid practice of cutting prices. If your business is to continue, and if you are to make a moderate profit out of your business, you must have a certain average rate of profit on your transactions, such that the sum it furnishes in the year will cover your expenses and leave you your modest profit. If you attempt to cut below this figure, whatever it may be, you will lose money and your business. If you attempt to cut your coat to your cloth, or, in other words, to make a profit by inferior work or materials, you will lose your business as soon as the results of your work have had time to show themselves. If you simply take the loss, carrying out the work as it should be done, you will lose your capital.

If anyone will look round at the firms that are now in existence that were in existence 10 or 20 years ago, he will find two characteristics invariably present. The work of these firms has been invariably good, and their prices have been high in comparison with those of other firms since deceased. These firms—those that are still standing—have marched well abreast of the times. Research and practical work have always gone together, and the research has been paid for, as it should be, out of the profits made on the practical work—that is to say, by the purchaser, for whose benefit the research was undertaken.

Young engineers, too, often fancy that they have a heaven-born genius for conducting business. No special knowledge is supposed to be required, no training, for what is perhaps the most difficult work that one can put one's hand to. Often the youngster thinks he will make up for the want of experience, both in business and in engineering, by the exercise of the very worst quality that a business man could be cursed with—that quality of sharpness, of over-reaching, that so many mistake for the necessary business quality of shrewdness—forethought. There is no necessity for any young electrical engineer who knows his work to go into business for himself. There are plenty of openings for properly trained engineers. An electrical engineer has only to master his work, as far as it is known, to strike a line for himself, and to go on working away as hard as head and body will let him, continuously, and he will be bound to succeed in the end. This success, too, will come at a time when he will most appreciate it, when Nature begins to warn him that the pace must not be so rapid, and in consequence of his success it need not be so rapid. If he goes into business and does not succeed—and few can—he will find himself thrown out of the race, and that many whose abilities were not equal to his have passed him; just as the hare found when he raced with the tortoise. We are apt not to look upon the tortoise as an animal to be admired, nor as one whose ways we should emulate, yet the way of the tortoise in the fable is the way to success in electrical engineering. Strike a bee line, as the Americans would say, and keep on pegging away.

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ELECTRIC LIGHT AND POWER.

BY ARTHUR F. GUY, ASSOC. MEM. INST. ELECTRICAL ENGINEERS.

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(Continued from page 559, Vol. XII.)

TRANSFORMERS.

From what has been stated regarding the features of high and low pressure distribution, it is at once apparent that the best way to distribute electric power over large areas with a limited loss, and also at the same time to introduce it into the consumer's premises at a low and safe voltage, is by using a combination of pressures, a high pressure being used for "distributing" purposes, and a low pressure being used on the "lamp" circuits. This can be effected in alternate-current work by the aid of what are named "transformers," and their object is to transform or convert small currents of high voltage into large currents of low voltage, and *vice versâ*; so that the electricity is sent out into the distributing mains at a high pressure, and where a tapping is made for a consumer, a transformer is connected up to the primary circuit to receive the high-pressure current while it gives out a low-pressure current, which is led into the secondary circuit, the current being thus transformed. A transformer which changes a current from a low pressure into a high pressure is termed a "step-up" transformer, and a transformer which changes a current from a high pressure into a low pressure is termed a "step-down" transformer.

Except for a small loss, the power received and the power given out are the same, so that when the pressure is decreased the current is increased; for example, a high-pressure current of 20 amperes at 2,000 volts is led into a "step-down" transformer, and if the winding on the core is such that the pressure is decreased to 200 volts then the current will be increased to 200 amperes, because $2{,}000 \times 20 = 200 \times 200 =$ watts. In its simplest form a transformer takes the form of an annular ring of iron, having a great number of turns of thin wire wound on one side and a small number of turns of coarse or thick wire wound on the opposite side—the thin wire is named the "primary" coil, and the thick wire the "secondary." The high-pressure current being led through the primary coil induces a low-pressure current in the secondary, or a low-pressure current being led through the secondary will induce a high-pressure current in the primary. These two windings are entirely distinct from each other, and well insulated from one another. Instead of the two windings being on opposite sides of the ring, one can be wound on the top of the other, in which case it is usual to wind the primary on first, the secondary being wound on top of the primary. Fig. 39 shows a ring with the primary and secondary on opposite sides, A representing the primary and B the secondary.

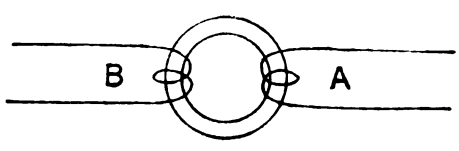

FIG. 39.

It is thus seen that an alternate-current transformer consists simply of copper and iron—copper to carry the electric current, and iron to carry the magnetic flux. The ratio between copper and iron for transformer design is a very nice point. As yet there does not seem to be sufficient practical data to warrant any decided ratio, and, in addition, this ratio would not be the same for all kinds of transformers: it would vary with the nature of the design, and also with the requirements of the transformer. Some design for high efficiency at heavy loads, others strive to produce one that will possess a high efficiency for low loads; others, again, prefer to design one that will give the best average efficiency for all loads. To give an idea, it may be assumed that a fair ratio between copper and iron is 1 : 2, and that 1lb. of copper and 2lb. of iron, or total of 3lb., will yield an output of 60 watts, or sufficient energy for one incandescent lamp of 16 c.p. This is at the rate of 20 watts per pound dead-weight, and applicable to a medium-sized transformer; one that would run, say, 100 incandescent lamps of 16 c.p., and thus have a total weight of 300lb.

It is necessary to fix transformers in a fireproof place, since they heat up very much when at work, the iron core becoming hot through "hysteresis" effects of the alternating current. This heating signifies so much loss of energy, and the greater this loss the less is the efficiency of the machine. The best modern transformers will now give an "efficiency" of between 96 and 97 per cent. at full load, and 94 per cent. at one quarter load. These figures are very satisfactory, and there does not seem to be much room for improvement as regards their efficiency at full load and half load. It is only when they are worked at light load that they become terribly wasteful, unless they are designed especially for light loads, and in that case they are not efficient with heavy loads. What is wanted is a transformer that will give a good efficiency for all loads, from full load down to a few lamps. The iron core of the transformer is always laminated, or built up, by using a number of thin sheets, as is the case in the construction of all alternate-current apparatus that contains iron, each sheet being insulated from the other by shellac, paper, etc., or some such suitable insulating material.

In high-tension alternating-current systems of distribution it is the present practice to "bank" transformers. By "banking" is meant grouping together in sub-stations. Thus there are two networks of distributing mains—(1) the high-pressure primary mains that ramify from the generating source, and (2) the low-pressure secondary mains that branch out from several determined centres, positioned at suitable places throughout the area to be supplied; it is at these centres where the sub-stations are built, each having a number of transformers, some large and some small. As the load increases, so transformers are switched into circuit, and as the load decreases they are switched out; hence it is necessary to have an attendant at each sub-station to watch the load and perform the above operations. By this device, no transformer need be at work with a light load, and by the aid of one or two small ones, to put in circuit when the load will not justify the employment of a large one, the losses are reduced considerably. It may be remarked that the core losses, or the loss of energy due to the heating of the iron, is almost independent of the load, and so when the load is light, they form much the greater part of the total loss of energy in the transformer. To protect the primary and secondary windings from an undue current, suitable fuses are inserted in the terminal-box of the transformer, a fine fuse being used for the primary and a thick one for the secondary. It is usual also, in some cases, to have the secondary coils wound in two windings, so that by the aid of a connecting strip in the terminal-box, the secondary can be at once connected up either in parallel or in series. In the former case the voltage may be, say, 50 volts, and in the latter case it would then be 100 volts, the transformer being applicable to either of the two pressures. It is not often in practice that the primary fuse "blows"; if it does, care should be taken that the primary coil be cut out of the high-pressure circuit before an attempt is made to replace the fuse. The secondary fuse is much more liable to blow, as it is direct on the lamp circuit.

Sub-stations are expensive places to build and equip with apparatus, and, in addition, the necessity of having attendants in charge makes their proper maintenance still more expensive; so that the presence of the transformer in alternate-current distribution materially reduces the saving that is gained by the employment of small conductors. Some go so far as to say that the cost of transformers comes to more than the saving that is effected in the cost of copper by employing small conductors for high-pressure currents, and however true this may be for limited areas, there seems to be no mistake about the fact that for large and extensive areas high-pressure alternating currents are preferable to three or five wire direct currents, in order to obtain a distribution of power in an economical manner and, above above all, with effective and good regulation for constant lamp pressure.

(To be continued.)

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METHOD OF SUPPLY.

BY G. OFFOR.

Managers of electric supply works have always two "prominent topics" to trouble them: (1) regularity and economy of supply; (2) how to increase the number of customers.

Upon the first point I have had, perhaps, less anxiety than many of my *confrères*, as the companies with which I have been connected having adopted the storage system of supply, it has never been my experience to deal with failure of the light through accidental stoppage of the generating machinery; but indirectly I have been affected by irregularities elsewhere, which have occasioned uneasiness as to the general character of electric supply.

Take the following conversation as an illustration: Speaking to a resident of Sydenham about his adopting the electric light, he remarked:

"I am afraid of it, for it is so uncertain. During my autumn holiday at the seaside, the electric light there was constantly going out, and while dining at South Kensington a short ago we were suddenly in darkness in the middle of our dinner."

"But such a thing could not happen in Sydenham under our system of storage," I replied.

"Oh," said he, "I cannot go into the question of 'system.' I know nothing about that, and until I am sure that you electric engineers have adopted a universal system of constant supply, like the gas companies, I shall hold off from spending money on wiring and fitting my house."

Another resident instanced the supply at two towns he had visited, where the electricity was only supplied during part of the 24 hours, so that if sudden darkness came on during the morning, or a lamp were wanted in the middle of the night, there was no light available.

These imperfect systems of supply no doubt create prejudices which cause an unfavourable public opinion, even in localities like Sydenham and Upper Norwood, Notting Hill, Chelsea, Oxford, etc., where electricity is supplied throughout the 24 hours continuously and with regularity by the aid of storage batteries. Economy of supply is, of course, of the utmost importance, but efficiency is still more essential; the most perfect system is the first consideration, and until this is universally accepted the difficulties I have alluded to will remain to vex the supply companies. But is it quite clear that the least effective systems are the most economical?

I suppose that all will admit that a supply based on a reserve of stored electricity is theoretically more perfect than absolute dependence upon the moving machinery. As in the case of gas, it is obviously more perfect to deliver from gasometers than direct from the retorts.

Assuming, then, that a continuous current with storage reserves is the most perfect system, it has been argued that for scattered districts the high-pressure alternating-current system is most suitable, owing to the economy and ease with which it can be distributed and converted at sub-stations or on the owner's premises into low pressure; but by the aid of motor-dynamos and accumulators the high-pressure continuous current can also be distributed economically over large and scattered districts, with the special advantage of the storage reserve and the running of the machinery always at full loads.

Upon the second point, all the supply companies experience the same difficulty in increasing the number of customers—viz., by the deterring effect of the first cost of installing the light. When the occupiers are also owners of property the question is a simple one, but with short tenancies there is a great hesitation in spending money in improving other people's property. To some extent the obvious advantages of the electric light induce people to incur the expense, whether owners or only occupiers; but if some equitable system were introduced under which the cost of wiring and fitting was defrayed by deferred payments, or undertaken by the supply companies on a similar hire system to that adopted in the loan of gas stoves by the gas companies, a very large addition to the customers would immediately take place.

WHERE IS OUR TELEGRAPHIC PROGRESS?

There is a strange absence of stir and advancement in the telegraph world. 1893 has been absolutely barren of anything to show that the United Kingdom holds its own at the head of inventive originality and progress in connection with the applications of electricity and mechanics to this one of the most useful of arts. Years have passed since the late Sir Francis Bolton, and later on Major Law, worked at multiple type-setting telegraphs for Press work; and yet, although from time to time we hear of some new start having been made in that direction, nothing worthy of being followed up by practical telegraphists is forthcoming. It is quite possible that the low cost of Press rates, introduced in 1870 by Mr. Scudamore, very much as a sop to conciliate the Press and secure their support to his great Telegraph Bill, has been the cause of want of stimulus to enterprise in that direction. If the use of a wire for Press work, costing the newspaper proprietors about one-tenth of what is charged for private work, was not so recklessly cheap, there can be little doubt that we should ere this have had many minds directed towards the combination and practical development of the beautiful mechanisms which have already been produced for transmission and simultaneous type-setting of news messages in large quantities and at high rates of speed. As to the Press telegram question generally, there is little doubt we should but for the occupation of the wires during the time outside the busy hours of the day with unprofitable (from a revenue point of view) news work, have long ago had the question of cheap "deferred," or "second-class," messages gone into by the postal telegraph authorities. The fact that this system was brought forward in a practical way by Major (now Major-General) Webber, R.E., in the seventies, as a witness before Dr. (now Lord) Playfair's Telegraph Committee of the House of Commons, and recommended by them, would seem to have given it a blow from which it has never recovered. But the unearned increment lying hid under the application of such a principle might bring joy to the heart of the present Chancellor of the Exchequer, if he would try and understand it, and let himself be advised by others than those pledged by their former adverse reports to find no good thing in it.

M.

CRANES AND CRABS.

Let not the gentle reader imagine that the above title implies a desire on the part of the *Electrical Engineer* to follow—*longo intervallo*—the lead of an enterprising and largely-sold monthly magazine, whose "Zig-Zags at the Zoo" are as popular a feature as any in the index of contents.

The appliances to be dealt with in this article are wholly inanimate, although their names may be due to the birds and crustacea whose characteristics they to some extent were evidently supposed to resemble, when first devised and named. It is, at any rate, interesting to see how the long neck of the bird "crane" is reproduced in the fixed or swinging jib of an inanimate iron crane; and how the sideways crawl of a crab may be noted in the traverse motion of any overhead travelling crane.

Putting philology aside, some brief consideration may first be given to the principal features of hoisting appliances in general, before proceeding to look into the question of operating these by means of electricity. It will be found on examining the subject that the "winch" or geared barrel forms the base of nearly all hoisting appliances; and, for the present purpose, this may be considered absolutely the case. It is so, at any rate, in all cranes for which electric power is likely to be employed, whilst the crab—which forms so essential a feature of overhead travellers—is practically nothing but a winch on wheels.

Of course, the main purpose of cranes of all sorts is the transference of goods or heavy articles from one place to

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another; and therefore the fundamental distinction between the different types may be considered to depend upon the ability of the hoisting apparatus to move bodily with the load or not. That is, roughly speaking, all cranes may be divided into two classes—locomotive and stationary. The latter would, of course, include jib or swing cranes, movable round a pivot, such as are in common use on board ship for unloading cargo, on quays, in warehouses, foundries, and workshops; whilst the former class, almost equally large, embraces cranes from railway breakdown appliances to overhead travellers, or the Titans employed on wharves and piers.

Each class, thus broadly indicated, contains a very large and varied assortment of types, and obviously, therefore, a complete description of these would take up too much time and space. A few only of the leading forms may with advantage be dealt with in order to show how far they have proved suitable for electrical working.

With regard to the class of fixed cranes, there seems to be no great economy promised from the use of electric power; in most cases the hoisting operations are carried on at intervals only, so that for small weights hand labour (with cheaper and simpler crane mechanism) serves every purpose; whilst heavy loads are lifted, as a rule, by steam power (also involving cheaper and perhaps less complex apparatus than in the case of electrical working).

Locomotive cranes, however, seem to offer a peculiarly suitable field for the employment of electric power, owing to the ease and economy with which the supply of electric energy is maintained from a source otherwise useful, say, for lighting purposes.

Any general criticism of one system as opposed to another—*e.g.*, steam or hydraulic power *v.* electricity—need, however, hardly be entered upon at this point, if at all; circumstances alter cases so much that a real comparison is by no means easily made, although efforts (more especially of late) have been put forward to reach a quantitative relation of economy between the three chief systems.

The cleanliness, ease of application, and average economy of electric working will always prove powerful factors in securing its adoption; this has already been proved by extensive use, more especially with overhead travelling cranes. We may therefore confine our attention to the latter for the present. Of course, the mechanical design and features of such appliances are practically the same as when steam applied direct, endless rope, square shaft, or other method is employed—that is, the general dimensions and speeds remain the same, even though the motive or actuating power may vary.

As instances of such may be taken the following, which are leading dimensions and particulars of a set of four electric overhead travellers recently built and installed for a locomotive works in the United States:

Building.	Maximum weight lifted.	Span.	Distance of travel longitudinally.	Speed, travel per min. Longitudinal.	Transverse.	Hoisting.
Erecting shop	40 tons	80ft.	500ft.	125-250ft.	100ft.	5-18ft.
Machine shop	10 tons	62ft.	350ft.	200ft.	100ft.	7-21ft.
Foundry	12 tons	50ft.	,,	,,	,,	,,
Boiler shop ...	20 tons	60ft.	—	,,	,,	6-12ft

It is curious, by the way, to note how extensive has been the application of electric cranes to locomotive shops, not only in the United States, but also in this country and on the Continent. The reason is obvious: very heavy weights—especially in the erecting shops—require lifting, and considerable power must therefore be exerted. The use of steam would prove costly and inconvenient: flying ropes have hitherto been preferred, but the constant waste of power involved by keeping these always in motion at high speeds proves also a serious objection. Now that so many works are being lighted by means of electricity it has become a matter of great ease to employ part of the current for operating the cranes; and thus all waste of power is avoided, as well as the care and attention required to keep in fair order the ropes and pulleys—always a source of dirt, and sometimes one of danger.

At the Crewe works of the London and North-Western Railway considerable use is now made of electric cranes their cleanliness and economy of working have given great satisfaction. Of those at work so far, the largest has a lifting power of 10 tons, and is operated (similarly to the others) by three distinct electric motors—one for each motion: lengthways, across, and lifting. This is a characteristic to which special attention may be directed, and later on the point will be discussed more fully.

The motors, which were made in the electrical department at Crewe works, are of the well-known "Manchester" type, with ring armatures running at 2,000 revolutions per minute. On each motor spindle is mounted a worm gearing into a worm wheel, so as to reduce the speeds. The cross traverse is thus worked at a speed of about 50ft. per minute, and the longitudinal about twice as fast. As a contrast to this type of crane may be mentioned one of nearly equal power now being completed by Messrs. J. G. Statter and Co., Limited, for the East and West India Docks. This is capable of lifting three tons at a speed of 20ft. per minute, or six tons at half that speed; the cross traverse of crab is made at a maximum of 60ft. per minute, and the longitudinal traverse at 80ft. per minute. A single electric motor is employed; it runs at 850 revolutions per minute, and drives the first motion shaft at 192 revolutions per minute by means of link belting of a section shaped to the rim of the pulley. A jockey pulley on the slack or under side of the belt, with double flanges, serves to tighten the belt as required to take up wear and stretch, and also helps to keep it on the pulleys in case of quickly-applied strains.

From the countershaft the motion is transferred to the three shafts operating the traverse and hoisting gears by means of friction cones. The difficulty sometimes experienced with gear clutches is therefore avoided.

(*To be continued.*)

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

SHUNTS.

SIR,—According to your contemporary *Lightning*, I have backed "H. L." in the matter of shunts, and I am further accredited with unassumed ignorance on the ground that I have criticised Kempe without understanding him. I am not, however, conscious of having backed "H. L." or affronted Kempe further than this—*i.e.*, that "H. L." is undoubtedly right in his contention that text-books tell us shunts *divert* current, and Kempe is undoubtedly wrong, as he falls into the same error. But I must admit, Sir, my ignorance and plead guilty to the charge brought against me by *Lightning*—which, however, I take it, is not forked, but a harmless form of discharge giving out light for too brief a period to have any practical value for good or ill. Your contemporary says: "His whole difficulties arise from the fact that, when Kempe is speaking of the E.M.F. in the circuit, 'Sidelight' understands him to mean that across the terminals of the galvanometer." This, Sir, reminds me of Mark Twain's account of his first interview with Bret Harte after, as no doubt you will remember, an early whisky cocktail, and my confusion is in no way inferior to his. If the E.M.F. in the circuit is not the E.M.F. across the terminals of the galvanometer, I have completely misunderstood "H. L.," and my remarks, like the galvanometer, must appear to be disconnected. Possibly the festive season is introducing a factor in our controversy, and a new reading of Ohm's law—*i.e.*, $\text{Clearness} = \frac{\text{Education}}{\text{Riotous living}}$—may explain the cross-purposes at which we now find ourselves. The main question at issue seems to me to be whether or not shunts *divert* or *split* current, and perhaps if we (I refer to your contemporary and myself) shunt cocktails for a week, and so divert the potentiality of our desire to split the harmony of—but, there, I'll say no more.—Yours, etc.,

January 3. SIDELIGHT.

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SHUNTS.

SIR,—I am writing the continuation of my letter in yours of December 29, within a few short hours of seeing that none too modest lucubration in print. I am ashamed of it; and yet the "of course" was enough to madden a sane man. It is the lip service of egotism; and when a man asks for bread and gets stones, he is naturally a little bit ruffled. I started fault-finding with definitions and explanations as given in the ordinary books, and am met with a snivelling "of course"; and having probably spent more hours than this critic has spent seconds in consideration of the subject, I am justified in resenting the sneer, "of course." But no more of this writer. Let me get to other grounds. "Sidelight" refers me to Kempe, an authority to whom all of us owe a debt of gratitude for his excellent work on testing. More power to his elbow! Yet Kempe, so far as I recollect him, or can see from another hasty glance at his fourth edition, fails in the particular I want. Examine Chapter IV.—on shunts. You will find it commences to discuss the proportions of the current which go through the shunt and galvanometer respectively, the multiplying power of the shunt and compensating resistances; then we come to joint resistances, and an examination as to the value of certain shunts and compensating resistances, etc. I do not find a single reference to the "of course"—pardon me, it slipped out unawares. I mean to say, there is no reference to diminution of acting pressure. Further examine the example on pp. 83-4, par. 82, entitled "The Equal Deflection Method."

"*Equal Deflection Method.*—The theory of this method is as follows: the galvanometer whose resistance, G, is required, a resistance, ρ, and a battery, E, of very low

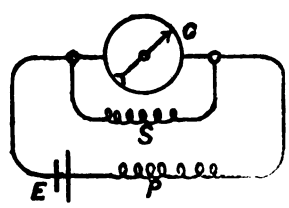

FIG. 37.

resistance, are joined up in circuit, as shown by Fig. 37, a shunt, S, being between the terminals of the galvanometer; a deflection of the galvanometer needle is produced. Let C be the current flowing out of the battery, then

$$C = \frac{E}{\rho + \frac{G S}{G + S}}.$$

This current divides into two parts—one part going through S, and the other part through the galvanometer. It does this in the inverse proportion of the resistance of those circuits; the part C_1 going through the galvanometer being

$$C_1 = \frac{E}{\rho + \frac{G S}{G + S}} \times \frac{S}{G + S} = \frac{E S}{S (G + \rho) + G \rho}.$$

"The shunt, S, is now removed; this causes the deflection of the galvanometer needle to be increased. ρ is now increased to R, so that the deflection becomes the same as it was previous to the removal of the shunt; or, in other words, so that the strength of the current passing through the galvanometer is C_1, then

$$C_1 = \frac{E}{R + G};$$

therefore

$$\frac{E S}{S (G + \rho) + G \rho} = \frac{E}{R + G}.$$

By dividing both sides by E and multiplying up, we get

$$S R + G S = G S + S \rho + G \rho;$$

therefore

$$G \rho = S R - S \rho,$$

from which

$$G = S \frac{R - \rho}{\rho}."$$

I find in these formulæ the symbol E, and ask my "of course" critic (it has slipped out again) if E in these formulæ has a variable value, or rather, if Kempe or any other author explains that it has a variable value. Perhaps I shall be told that, for simplicity's sake, writers *assume* E to be constant, while they, "of course," know it is variable. If that is so, am I not justified in calling attention to inaccuracies in the books ordinarily used, and seeking to find one which shall give me a full explanation of the subject? I am certainly not anxious to show my own ignorance, but I mean to find out where I or the books are wrong. Consider the case diagrammatically:

First.—Let A B represent an homogeneous conductor resistance, and A C the total pressure of the battery. Suppose, in the first instance, the battery to be a large secondary with many cells in parallel, so that internal resistance may fairly be neglected.

Join C B.

Then C B will represent the fall of pressure through the circuit. This fall is regular, and a perpendicular upon A B, touching C B, will show the pressure acting at that point in the circuit. Let E F be such a perpendicular at any point, E. Then E F represents the acting pressure at E, and if from F we draw F G parallel to A B, cutting A C in G, then G C shows the loss of pressure over that part of the circuit indicated by A E.

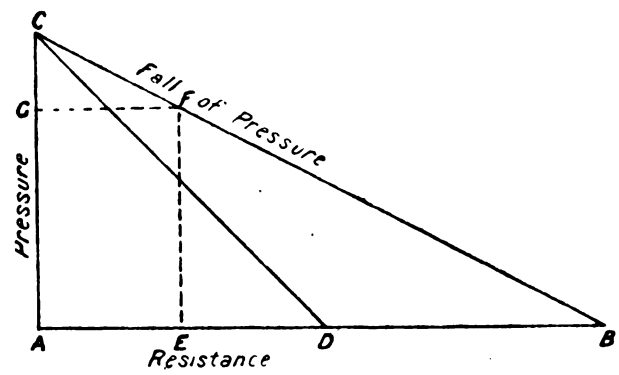

Fig 1

Suppose A B represent the galvanometer resistance.

Now put in a shunt of similar conductor and equal resistance. The total resistance of the circuit will be halved, and may be represented by A D = ½ A B.

Join C D.

In the new circuit, C D represents the fall of pressure.

By Ohm's law, current = $\frac{\text{pressure}}{\text{resistance}}$.

Let C, E, and R represent respectively current, pressure, and resistance.

In the first case $C = \frac{E}{R} = \frac{A C}{A B}$,

In the second case $C_1 = \frac{A C}{A D} = \frac{A C}{\frac{1}{2} A B}$,

whence it will be seen $C_1 = 2 C$, or current is doubled; equal parts going through shunt and galvanometer—*i.e.*, by the insertion of the shunt, no change at all has been made as to current through the galvanometer. Am I so far correct?

Secondly.—Now let us take a case where internal resistance may not be neglected, and where there are other resistances besides the galvanometer and shunt.

Let A C represent the total pressure of battery.

Let A D represent the internal resistance of battery.

Let D B represent the external homogeneous conductor resistance of circuit.

Join C B.

Then C B may represent the fall of pressure through the circuit. From D draw D E perpendicular to A B, cutting C B in E. Then D E represents the pressure acting on the external circuit, and A C − D E = loss of pressure to overcome internal resistance. Take any point

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F in the external circuit. Draw F H parallel to D E. Then F H indicates the pressure acting at the point F, and D E – F H represents the loss of pressure required to overcome the resistance D F. Similarly, G N represents pressure acting at G.

From E, H, N respectively draw lines parallel to A B, cutting A C in R, P, Q respectively,

Then C R represents pressure used up by resistance A D.
R P " " " " D F.
P Q " " " " F G.
Q A " " " " G B.

Now is it true that so long as the resistances A D, D F are constant, so long will they use up pressure indicated by C R, R P, or the total C P, leaving F H or A P acting at F?

Suppose F to indicate one terminal of a galvanometer and G the other terminal.

We require pressure A Q to overcome resistance G B; so we have pressure, indicated by P Q = H O, acting on the galvanometer. The pressure, resistance, and fall of pressure, so far as the galvanometer is concerned, may be represented by H O N; where H O is the acting pressure, O N the resistance of the galvanometer, and H N the fall through the galvanometer circuit.

We have seen (Case 1) that insertion of an equal and similar resistance to the galvanometer merely causes a more rapid drop in the pressure with a corresponding increase of current.

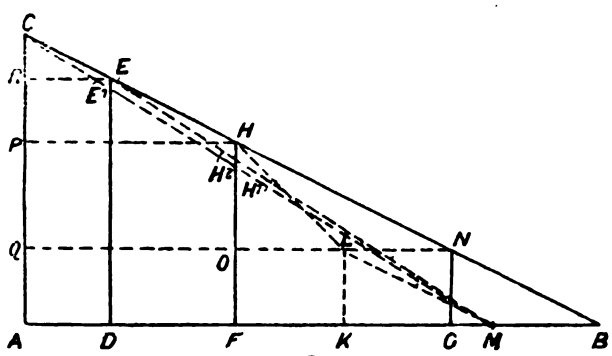

Fig. 2.

Insert such a shunt between F G. This reduces the resistance between the points F G to one-half what it was before. Let the new resistance be indicated by F K or O L.

Join H L.

Then under the new conditions, H L shows the fall of pressure. Through L draw L M parallel to N B, meeting A B in M.

Then L M indicates, as does N B, the fall of pressure due to resistance, K M = G B.

A M may be taken to represent the total resistance of the whole circuit after insertion of shunt.

Join C M, and taking the circuit as a whole, will C M show the fall of potential? If it does, we at once see that the pressures acting at the points, D, F, have lessened to D E_1 and F H_1.

But at the outset I shall probably be told, with good reason, that this is wrong, and that I should join E M, not C M; and in this case, if the argument be right, F H_2, not F H_1, is the acting pressure after the shunt is inserted.

Will some kind reader tell me am I so far correct?

Thirdly.—May we not take it that the total pressure of the battery has nothing to do with the difficulty, and that of this total pressure a constant part is absorbed by internal resistance without being affected by changes in the external resistance. So for all practical purposes of the kind discussed, all we have to consider is the pressure acting on external circuit which is a constant. I cannot for a moment see why, under any variations in the external circuit, there should be a different fall of pressure due to internal work. If I am wrong, I want to know it! Assuming I am correct, then

D E, Fig. 2, or Fig. 3, is constant.

Let D B, Fig. 3, represent the resistance of galvanometer, with no other external resistance, such as D F, G B, Fig. 2.

Can any shunting of D B interfere with current in D B, and if so, how? If the shunt be of equal resistance to the galvanometer, then D K = ½ B D represents resistance, and the current is doubled, the second half of current going through the shunt with no change in the galvanometer.

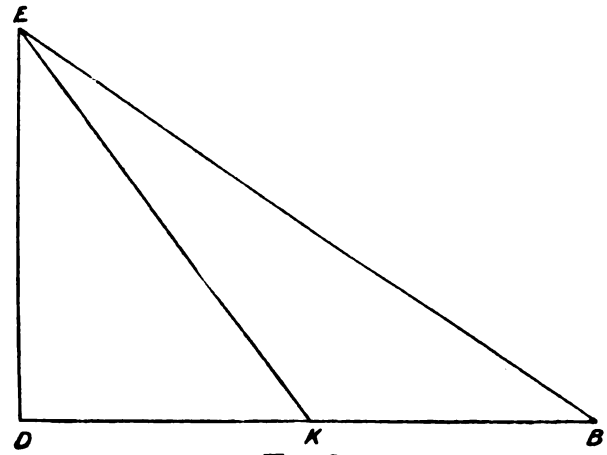

Fig. 3.

Now, Sir, your obtuse "of course" friend, I should say wilfully mistook what you said—as he must have wilfully quoted another contemporary in the same issue instead of you. Indeed, to the outsider this seeming wilful misrepresentation is puzzling to account for. "Of Course" has a chance to explain everything. You have not done much towards explanation except to agree that with "pressure constant," shunts won't affect the original circuit. So far as my reading goes, no book tells me how to get the new pressure if pressure is variable. Is it something like $\frac{D\,E}{D\,M}$ tan E M D? Fig. 2.

Fourthly.—Actually, are we not taught by our books to do something like this?

In Fig. 4, let D E = acting pressure;
D K = resistance of shunted galvanometer;
K B = resistance of compensating resistance.

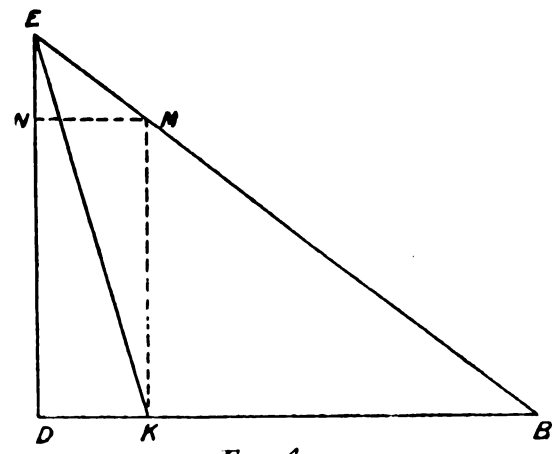

Fig 4

With shunted galvanometer alone, E K represents fall of pressure. With shunted galvanometer and compensating resistance, E B represents fall of pressure, and here E M represents fall of pressure through shunted galvanometer part of circuit, and E N shows acting pressure through galvanometer circuit.

Once more, Sir, I would like to know where to find all about these things. I started cussing books and teachers for wasted money and time—and thank Mr. Walker and "Sidelight" for their contributions to help me; but perhaps I have at last shown the maze into which I have fallen. Who will help me out?—Yours, etc., H. L.

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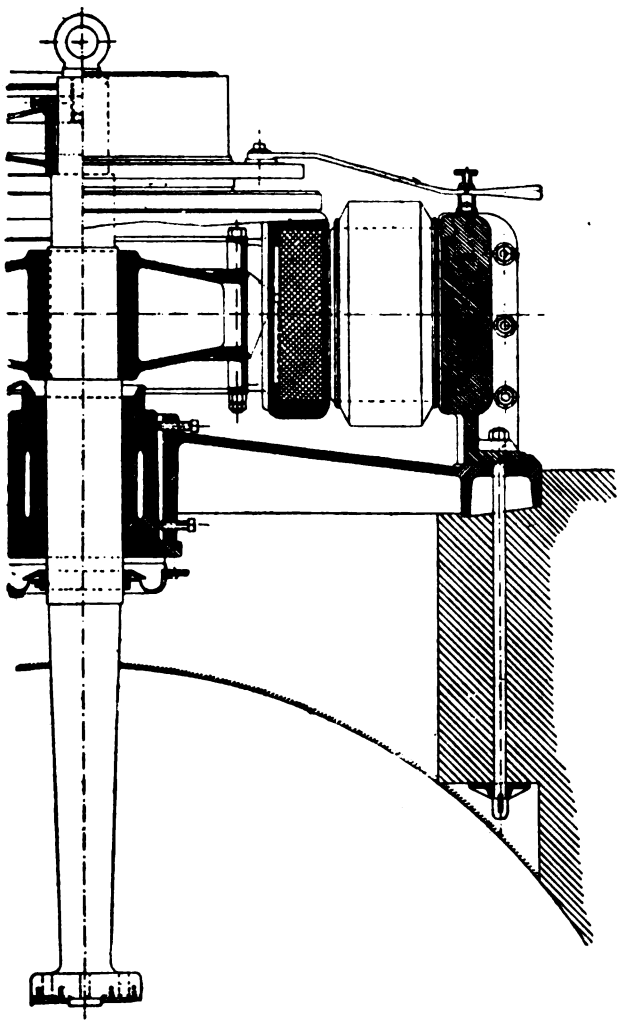
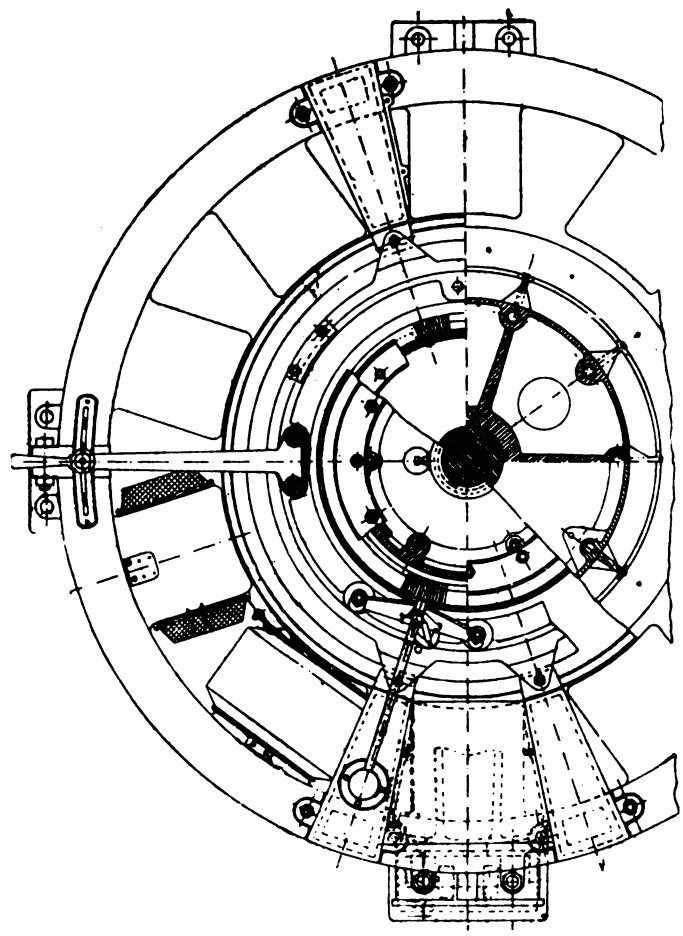
"PROF. FORBES ON HIS CRITICS."

SIR,—The letter from Prof. Forbes in your issue of the 29th ult. raises the important question, "Shall papers read before scientific societies be criticised or not?" Apparently Prof. Forbes's opinion is that only favourable criticism is permissible. He also objects to give any further information necessary for the intelligent discussion of his paper. Several speakers asked for such further information, and were duly rebuked. My own case was as follows: I found on investigation that Prof. Forbes's conduit was liable to two principal difficulties, either of which can be reduced at the expense of the other. The one is the danger of flashing across between the two conductors of the same circuit if placed on the same side of the conduit. The other is the effect of mutual induction between the two circuits if all the leads are carried on one side and all the return wires on the other side of the conduit. The mutual induction would, I found, prejudicially affect the working of the system. It was therefore necessary for me to ask Prof. Forbes which of these arrangements he had adopted, as the information was not given in the paper. He replied to my query, "I decline to answer that." I will leave your readers to decide whether this remark was justified.



Oerlikon Dynamo.—Sectional Elevation.



Oerlikon Dynamo.—Plan.

Turning to the vexed question of the general policy of the Niagara Construction Corporation, it would be to the point if Prof. Forbes would tell us a little more about the "disbursements of 90,000dol. for European professional advice." How much of this was paid to the members of the first commission held in Exhibition-road, whose report was not carried out, and how much to manufacturers? This commission consisted of many eminent men, who would require a large fee for their valuable assistance both by name and professionally. Any money paid them, although it may have been a large amount, on account of valuable information not used would not give much satisfaction to electrical firms who have spent some thousands of pounds (not dollars) in preparing schemes only good enough to be of general use to Prof. Forbes as adviser of the Cataract Construction Corporation. That he received such assistance from plans submitted is acknowledged by him in his paper, where he claims no great original work in the design of the machinery. In fact, it would be of great interest to know how many thousand dollars have been received by European manufacturers—not consulting engineers—for professional advice. Still, from what I remember, Mr. Ferranti in his condemnation of the policy of the company did not blame Prof. Forbes personally, and I consider that the personal element in the discussion was not introduced by the critics.

As regards the statement that Prof. Forbes's alternator is like a "Brown" machine, I would ask you to reproduce, if possible, the blocks given on pages 345 and 346 of Mr. Gisbert Kapp's book on "Dynamos, Alternators, and Transformers." I must confess that when I accidentally came across a "pull" from this block the other day I thought it was the Forbes machine. The electrical and magnetic parts are similar, but the mechanical details differ, as the armature of this dynamo revolves inside a fixed field. Electrically the difference is zero, but the balance in favour of the fixed field may explain Mr. C. E. L. Brown's condemnation of the Forbes design. The construction of the bearing inside the armature is the doubtful point, and the attendant who entered the space inside the armature (so much thought of by the designer) to attend to this bearing if heating, would take his life in his hands. The confined space with, say, melted white metal flying round, and 24 tons of iron travelling at 100 miles per hour all round you, would be a trifle too hot for a nervous man. The Brown machine was certainly a direct-current one, but the alteration necessary to evolve the two-phased windings is not a large matter.

I do not blame Prof. Forbes for using, as he must involuntarily do, the information obtained from the designs sent in and from the many works he visited when retained by the Niagara Construction Corporation; but we European engineers have a just right to grumble when this informa-

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tion is placed at the disposal of an American firm who, we are given to understand, are afraid to work at more than 2,000 volts.

Also, was it good taste or professional etiquette to turn on Mr. W. M. Mordey as Prof. Forbes did in his reply, after having been allowed the privilege of experimenting on the Mordey alternator?—Yours, etc.,

R. W. WEEKES.

Westminster, January 3, 1894.

ELECTRIC TRACTION AND THE BOARD OF TRADE.

SIR,—Since the publication of the draft Board of Trade regulations for electric tramways, we have been expecting to find attention called in the Press to the serious bearing these regulations, if confirmed, will have on the infant industry of electric traction. But, much to our surprise, the matter seems to have escaped notice, and we, therefore, crave space for a few remarks on the subject.

In the first place, the regulations appear to us to be out of harmony with the report of the joint committee which considered the traction question last June, and which recommended that the Board of Trade should draw up rules calculated to give effect to the committee's views. The following extracts from the report clearly indicate the committee's intentions, the italics being ours: "The committee, having regard to the evidence before them, are of opinion that it is not, in the present state of electrical science, in the interest of the public to insist upon electrical tramways using an insulated return conductor, and that such insistance would retard the development of electric traction." "The undertakers shall take all reasonable and proper precautions in constructing and using their lines, circuits, and other works, so as not injuriously to interfere with the working of any wire, line, or apparatus . . . . provided always the undertakers shall be deemed to take all such reasonable and proper precautions as aforesaid, if and so long as they adopt and employ, at the option of the undertakers, either such insulated returns or such uninsulated metallic returns of low resistance, and such other means of preventing injurious interference with the electric wires, lines, and apparatus of other parties and the currents therein as the Board of Trade shall direct, and in giving such directions the Board *shall have regard to the expense involved, and to the effect thereof upon the commercial prospects of the undertaking.*" The Board of Trade are empowered by Section 3 of the report to make rules "for regulating the employment of insulated returns or of uninsulated metallic returns of low resistance, for preventing fusion or injurious electrolytic action on gas or water pipes, or other metallic pipes, structures, or substances, and for minimising *as far as is reasonably practicable*, injurious interference with the electric wires, lines, or apparatus of other parties, whether such lines do or do not use the earth as a return." In their third and fourth recommendations the committee express themselves altogether in favour of metallic circuits for telephones and railway block signals. Briefly, the committee considered that although every reasonable precaution was to be adopted in favour of earthed telephones and water-pipes, the existence of these things was not to stop nor even to hamper electric traction. The Board of Trade respond to this expressed intention by proposing their regulation No. 14: "In the disposition, connections, and working of feeders the company (undertakers) shall avoid injurious interferences with any existing wires." This was exactly the view of the National Telephone Company when they tried to stop the Leeds tramway. It was a view they could not persuade Mr. Justice Kekewich to adopt, it was a view they could not persuade the joint committee to adopt; and yet after everything that has passed, the Board of Trade calmly go back to it, and seek to make it law. There is no qualification such as the committee indicated to the proposed regulation, and its adoption will place electric traction in a worse position than ever. By regulation No. 15, "sparking at the rubbing and rolling contacts in any part" is absolutely forbidden. Is that "reasonably practicable"? We say that it is not. The indifference displayed by the electrical profession in the matter may be perhaps due to the knowledge that the Board of Trade intend to take the opinion of the Council of the Institution of Electrical Engineers on the regulations before issuing them; but a word of warning appears necessary on this point. The National Telephone Company are most influentially represented on the Council by gentlemen who are, or have been, their retained experts. No doubt it may be said that these gentlemen will not allow their conduct at the Council to be influenced by their retainers, but can they avoid insensible bias, and would it be just to their employers if they did? We would suggest that the only proper course is for the Council to exclude all such partisans, whether for or against traction or telephones, from their deliberations when the rules are under consideration. That the National Telephone Company are alive to the occasion would appear to stand confessed by the circular-letter issued from their offices on December 8 to their employés and others, suggesting that they should substitute on their ballot-papers the name of one of the company's officials for that of one of the Council's candidates, and also endeavour to influence their friends to do the same. The manœuvre did not succeed, but it is significant. It is also noteworthy that the list of Mr. Ansell's proposed representative council does not include any member for traction, whilst telegraphs and telephones are to be provided with three.—Yours, etc.,

Preston, Dec. 30, 1893. BENNETT AND DRUCE.

LIGHTING OF KINGSWOOD.—A CORRECTION.

SIR,—The directors of the Western Counties Electric Light and Power Syndicate, Limited, have had their attention called to the report contained in your issue of the 22nd ult., under the heading of "Kingswood," in which a statement occurs that at a meeting of the Local Board complaints were made as to the inferior lighting of the district, and that the answer was that the current was at fault.

I am instructed by my directors to write you at once, requesting you to be kind enough to insert a total denial of any statement as to the inferior quality of the lighting or the current being at fault. The fact is that the lighting at Kingswood will compare favourably with the electric lighting of any town in the kingdom. As a matter of fact, in some of the by-streets the lamps supplied are of only 25 c.p., that being the power required by the Kingswood Local Board, and contracted for by Messrs. Parfitt and Son, who have sold their patents and business to the syndicate. The Local Board were told at the time that lamps of only 25 c.p. would not be satisfactory; but the Local Board did not feel justified in paying for lamps giving greater light, and the contract was carried out by Messrs. Parfitt and Son in accordance with the terms required by the Local Board. There is no cause whatever for any complaint, and, indeed, the syndicate have supplied more light than that contracted for.

Some few months ago complaints were made by some of the residents that the lighting in these by-streets was not sufficient (as was anticipated would be the result by Mr. Parfitt when he warned the Local Board against having lamps of such small candle-power), and it was then arranged that the surveyor of the Local Board, with the engineer to the syndicate, should examine and test each lamp in the district. The result was that some of the lamps were found to give 31 c.p., and no lamp was found to give less than 28 c.p., so that it will be seen that in no case was there given less than 3 c.p. above that contracted for, and in many cases as much as 6 c.p. above.

My directors, therefore, consider that complaints are both unfair and improper, and I am sure you will concur with me, that inasmuch as you have unintentionally done an injustice to the syndicate by inserting the paragraph, you will at once remedy the injustice by inserting this contradiction.

I may add that in the main streets lamps of 120 c.p. are supplied, and the light is as brilliant and as good as can be found anywhere in England; indeed, the highest authority on electric lighting in the kingdom has reported in the most eulogistic terms both upon the system and the light.—Yours, etc., S. F. ANDREWS, Secretary.

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THE
ELECTRICAL ENGINEER.

Published every Friday.

Price Threepence; Post Free, Threepence Halfpenny.

Editorial and Publishing Offices:

39-140, SALISBURY COURT, FLEET STREET,

LONDON, E.C.

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1893 PAST—1894 PRESENT.

"Hearty Good Wishes."

A review of the year naturally recalls the topics dealt with twelve months ago, to find many of them as prominent—some more so—at the present time as in last January. A constant stream of enquirers ask how best to prepare their sons for taking a good position in the electrical industry, and have to be answered in due course. We have thought it would be well if all employers of labour would print in large type, and keep conspicuously before all enquirers as to opportunities in the industry, a paragraph from one of Mark Twain's replies. We will parody the reply, in order to apply it to our particular needs, and would make it read thus:

"Electrical engineering, like all other professions and all other occupations, is cramped and hindered for want of men to do the work, not for want of work to do. When people tell you the reverse, they say what is not true. If you desire to test this, you only need hunt up a *first-class* designer, manager, foreman, or mechanic in any branch of the industry, and *try to hire him.* You will find he is already hired. He is sober, industrious, capable, and reliable, and is always in demand. He cannot get a day's holiday except by courtesy of his employer, or of his city, or as by law proclaimed. But if you need idlers, shirkers, half-instructed, unambitious, just-as-good-as-my-neighbour men, apply anywhere. There are millions of them to be had at the dropping of a handkerchief."

Is not this too true? Is there a master or a conscientious manager who is not driven almost crazy because of the lackadaisical attitude of the men he has to employ? Can he give general instructions as to the work to be done and leave his men in the sure and certain hope that the work will be well and correctly done? He can't. Half of the bad work of the present day is not because the masters and managers desire bad work, but because many of the men they employ have no spark of morality in their whole composition. One of the technical papers the other day reproduced a large number of mason's marks. These marks, if they indicate anything, indicate that the labourer took a pride in his work, and was proud to indicate to all and sundry the particular part of the building for which he would take credit. The majority of men engaged in the electrical industry would not care to specially indicate their work, and if they did indicate it, the work would not bear inspection nor win any credit. And this is towards the close of the nineteenth century—an age said to be civilised, when compulsory education holds sway, and trades unions govern the land. Well, there is plenty of work for first-class men, and for our part we would suggest that those who are satisfied to be as good as their neighbour ought to be urged to emigrate. Self-help is a lost cry nowadays, but it is useful in the long run; and though in one sense knowledge may not be power, it is a great factor in determining a man's position.

"Nil admirari, prope res est una,
Solaque, quæ possit facere et servare beatum."

Thus Horace says, and his words have been rendered:

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"Not to admire, is of all means the best,
The only means, to make and keep us blest."

We certainly are amongst those who do not admire all the tactics of these days.

Mark Twain's term "first class" brings to our mind an important consideration referring to consulting engineers. We fear some municipalities are providing a rod for their own backs, and are certainly employing consulting engineers that can by no stretch of the imagination be termed first class. It has long been a question for us whether a deliberate libel would not be the best way to deliver the profession from quacks—but why should we pluck the chestnuts from the fire when professional men remain silent themselves? Central stations exist which are known to be wrongly designed, which will surely lead to municipal troubles, which indicate most clearly incapacity to understand the requirements of the position and place, while it is impossible to say the apparatus used is not good. We think we could show in more than one case that each average horse-power year must earn from £50 to £250 net profit in the year to obtain satisfactory pecuniary results. Is this possible with electric light or power work? Mr. Crompton might tell us what a horse-power year ought to bring, not only from estimate, but from experience, for probably his records at Kensington are as extensive, detailed, and complete as any that exist. If with a given initial outlay a sufficiency of power is not provided—that is, earning capacity is unprovided—how can a station pay? And this provision is one of design, and has nothing to do with the excellence of the apparatus provided. In other words, a station may be equipped with the best of everything, and yet unable to pay its way. The one great fault is the weakness of the consultant, who on purpose to obtain work plays to the gallery, instead of designing for futurity. The saving of an initial expenditure of five thousand pounds means probably an altogether unnecessary expenditure of twenty thousand within five or six years. Thus the consultant who advises properly is unemployed because a brother professional troubles nothing for the future and plays all his cards for the immediate present. The latter takes as his motto another of Horace's sayings—*vide* Epistle to Mæcenas—wherein he is advised thus:

"My friend, get money; get a large estate
By honest means; but get, at any rate."

Speaking of central stations, we would remind our readers that probably more money is spent upon wiring and fittings than upon apparatus in the station and the mains. The manufacture of meters has attained very large proportions; but these are generally hired, and their purchase forms part of the outlay of the supply concern. The wiring and fittings, however, are very often the work of outsiders, and upon this work the success or failure of the central station too often depends. It is all very well to argue that current will not be laid on till the inspector from the central station is satisfied with the work. The inspector is but mortal, and cannot do impossibilities. Things made to sell generally look all right, and things made to pass an examination very often pass, and afterwards develop faults which are directly due to bad workmanship or materials. That both are common no one denies. Two anecdotes may be told to confirm this. Not long since a responsible manager said of a firm that was cutting a dash and doing a large amount of wiring: "That firm's work is known to be anything but good; yet there it is, and it is passed." Again, a firm trying to make a reputation for good work, being asked to purchase certain materials from a nicely got-up price-list, said, "No, these materials are by no known maker; and we refuse to purchase unless we know the makers and that they are of good repute." The central station has enough cares of its own without suffering for the sins of other people; yet any failure is laid at its door, and in many instances householders delay putting in the light because a friend or neighbour records a variety of failures. The most perfectly designed and equipped central station cannot guard against these evils. In connection with central-station design we are becoming daily more convinced that insufficient attention has been given to storage. This may seem a wild statement; but we will take the doubter to more than one station where facts would, we think, prove too strong for any abstract theory as to what ought to be, but is not.

Mr. G. Offor points out on another page that the idea of certainty in electric light matters is not yet impressed upon men's minds. Indeed, the general opinion is to the contrary, that it is uncertain, and a whole cartload of facts and statistics will not mend matters. Give a lie a start of twenty-four hours and you will never overtake it, so that, in like manner, if we give as a fact one lamp being out for five minutes, the history of that lamp will swell into all the lights of the house, street, or town out for an hour. No doubt our contemporaries, like ourselves, are inundated with trivial complaints, in which molehills are made to appear as mountains, and which after being sifted are found wanting and go unrecorded, except when the rumour gets into the hands of the gas journalist. Every effort should, then, be made to have wiring, fittings, distribution, and central-station apparatus as perfect as possible. It is not enough to trust that things will continue all right because they went all right yesterday. Supervision should be untiring, keen, and exhaustive. Even then the design of many stations leaves out storage, and is content with a reserve of apparatus. Is it not a fact that initial simplicity has very much to say for the booming of high-pressure systems? Are we sure, and do facts and figures carry conviction, that transforming up and transforming down losses here and losses there means economy? Shall we come to the time when a reserve of apparatus, rather than a reserve of storage, will not bring—

"Weeping, weeping, late and early;
Walking up and pacing down,"

and a mourning deep as can be in business matters? The engineers in charge of central stations and the managers of supply companies, if they were to tell the truth, would, without exception, say, "Give us at any rate some storage." Reserve machinery means time lost to get into action. Storage means a turn of a switch and time to bring other reserves

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into play. But, of course, there is always the question of initial cost, as well as simplicity, and hitherto the advocates of high pressure have obtained favourable consideration.

Another question of the first importance has been touched on by Mr. Mordey in a letter to us. Every word of his statement seems to us important. It is as follows: "It appears to me that the electrical engineering business is changing rather in the distribution of work, than in any other way—large contracts for all sorts of plant going to the large manufacturing concerns, and small separate installations, wiring work and special applications to the smaller concerns and to those who specialise. I think there is, perhaps, a growing inclination to adopt the plant and practice of the larger concerns throughout for entire jobs, rather than dividing such jobs up amongst a number of firms. This is as it should be, as it places the bulk of the responsibility on one instead of on a number, and prevents waste of money and time caused by a number of contractors having to work together on one job."

The question of design again comes in, and if the consultant specifies certain boilers—*e.g.*, because they have been made fashionable by adoption in certain quarters—without knowing much about boilers himself, he is likely to err. We have long insisted that the throwing together an installation is a mistake. Every part should be designed in connection with every other part, and when so done the result is more likely to be satisfactory than when engines, boilers, dynamos, etc., are selected either because of cheapness or of fashion. The concentration of responsibility is much to be desired. An example of the value of this is seen in the success of the Liverpool Overhead Railway, where the company is so satisfied with the work of the contractors that it has taken over responsibility before the time originally specified for doing so.

Our desultory remarks must, however, come to an end. We had intended to say something about ourselves, but that subject, though it may be interesting to individuals, is of no special interest to the general reader. We are told that we have been tolerably good in the past, and if we promise to behave better in the future—what more can be expected? As usual, we have collected a number of reports from a variety of companies and firms connected with the industry, which follow hereafter:

J. E. H. Andrew and Co. state that during the year they have supplied engines for about 25 private installations, a total of 300 effective horse-power, which would be equal to 3,000 16-c.p. lamps. Among other places, they have supplied two engines, 57 effective horse-power, Paragon Music Hall, London; one engine, 35½ effective horse-power, Bow Theatre, London; two engines, 22 effective horse-power, Arcadia, Devonport, Plymouth; one engine, 20 effective horse-power, Lads' Club, Denton; one engine, 20 effective horse-power, Hengler's Circus, Dublin—or a total of 154 effective horse-power, say 1,500 16-c.p. lamps. In addition to this they have done a considerable amount of exhibition lighting at various times of the year with engines from 2 to 55 effective horse-power—for example, 55 effective horse-power for driving direct arc lighting at the last Brewers' Exhibition, Stanley Show, and the Fat Cattle Show at the Agricultural Hall. They have a considerable number of engines on order at the present time, and are hopeful as to the prospects of the coming year, and with special reference to gas-engines for electric lighting they consider the use of them is decidedly on the increase, and during the next year a very extended use will be made of the gas-engine for central-station work. They have a special tandem-cylinder engine now manufacturing, which they contend is well adapted for driving dynamos for direct lighting, and anticipate a large share of the orders for central-station work with this improved type of gas-motor.

R. Aylmer reports that though this is the first year of introducing the new Leclanché-Barbier batteries, they have met with great success, and are being largely used by many of the railway, telegraph, telephone, cable, and other companies, scientific institutions, Indian and colonial governments, and electrical engineers, as well as by a considerable number of private firms.

Browett, Lindley, and Co.—During the past year this firm have had their full share of work, and amongst other contracts which they have executed may be mentioned all the steam-engines for driving the electric light station at Derby, to the order of Messrs. Siemens Bros. and Co., Limited, London; two high-speed horizontal engines for Coventry electric trams (overhead wire system), to the order of the Electric and General Contract Corporation, Limited, Westminster; two engines for the City of London electric light station, coupled direct to the General Electric Company's dynamos, and built to the order of the Laing, Wharton, and Down Construction Syndicate, Limited, Westminster; three engines for driving the electric light installation at the palace of his Majesty the Shah of Persia. Besides the above they have during the past year supplied many electric light engines to the order of their agents in Spain, Italy, Russia, and Austria, as well as a large number to the leading electrical firms for shiplighting and land installations. In addition to the above electric light work, the company have had a good supply of orders for horizontal and other types of engines for general commercial purposes, including a pair of vertical single-acting engines of 350 h.p. for direct coupling to a colliery ventilating-fan. The prospects for the coming year are extremely satisfactory, the company having in hand a large number of orders for the trade and private customers, including the engines for the Mullingar Lunatic Asylum (Ireland), engines for the Lancashire and Yorkshire Railway Company for shiplighting (third order), and about 40 other engines for shiplighting plants, etc. In central-station work they will also be very busy, having in hand the first of three 250-h.p. vertical compound engines, for the extension of the Derby town lighting, to the order of Messrs. Siemens Bros. and Co., Limited, of London; the whole of the steam-engines and condensing plant and accessories for Ealing central electric light station, to the order of Messrs. Latimer Clark, Muirhead, and Co., Limited, Westminster; the whole of the engines and condensing plant for the Chiswick central electric light station, to the order of Messrs. Bourne and Grant, London; the whole of the horizontal engines, etc., included in Contract 3 for the Corporation of Salford electric light station; the whole of the engines for Southport Corporation electric light station. It is only some two years since the company removed their business from Salford to their far more extensive

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works at Patricroft, which are already taxed to their utmost capacity, and further extensions are already in contemplation.

BUMSTED AND CHANDLER.—This firm have during the past year supplied their well-known electric light engines, forced-draught fans, and ventilating-fans to a large number of steamships and steam-yachts, among which we may mention the Belgian Government mail steamers "Marie Henriette" and "Leopold II."; the London and North-Western Railway Company's steamer "Eleanor"; the Glasgow and South-Western Railway Company's steamers "Minerva" and "Glen Rosa"; the County Down Railway Company's steamer "Sleeve Douard"; the Thames, Woolwich, and Clacton Steamboat Company's steamer "London Belle"; Sir John Burns's Royal Mail steamer "Hound"; ss. "Tamboff" belonging to the Russian Volunteer Fleet; Messrs. W. Cory and Sons' steam-pontoon "Atlas No. 2"; the Bergen Steamship Company's steamer "Capella"; Baron Arthur de Rothschild's steam-yacht "Aries"; Mr. G. W. Fowler's steam-yacht "Puritan"; the White Star Company's ss. "Gothic"; the Lancashire and Yorkshire Railway Company's twin-screw steamer "Duke of York"; the Samuel Petroleum Syndicate bulk-oil steamers "Bullmouth," "Clam," "Elan," "Volute," "Trocas," and "Spondilus"; Messrs. M. Langland and Sons' steamer "Princess Beatrice"; the Portuguese Navigation Company's ss. "Zaire"; Messrs. J. and H. Harrison's ss. "Barrister"; the Chesapeake and Ohio Railway Company's ss. "Acanthus"; Mr. James Gordon Bennett's steam-yacht "Namouna"; and a mail steamer belonging to the Turkish Government. Electric light engines have also been supplied for a large number of land installations, among which we may mention the Woolwich electric light station, the London and North-Western Railway Company's rail mills at Crewe and at their pier at Holyhead Harbour, the North Stafford Railway Company's station at Stoke-on-Trent and their hotel at the same town, and Birch Hall, the seat of Mr. Buxton.

CLARKE, CHAPMAN, AND CO.—This firm has done a considerable amount of work during the year, principally in connection with the lighting of ships. The following is a brief summary: The s.s. "Baker Standard" has been installed with 80 16-c.p. and four miners' hand lamps; the "Mackay Bennett" has been fitted with a search-light projector complete; the "Trocas" has been fitted with a direct-coupled plant giving 1,800 watts, with 77 16-c.p. lamps, and a complete Suez Canal plant; the "Clam" has been also fitted with a direct-coupled plant of 70 16-c.p. lamps and two 200-c.p. lamps, and a complete Suez Canal plant; the "Spondilus" has been supplied with the necessary plant—viz., 60 16-c.p. and two 200-c.p. lamps, and a Suez Canal plant; the "James Brand" has been fitted with 84 16-c.p. lamps, and the necessary dynamos; the "Midnight Sun" was fitted with 350 16-c.p. lamps; the "Lucigen" with 88 16-c.p. lamps; the "Ronold" with 204 25-c.p. lamps, and an 18-unit direct-coupled plant; the "Mexican Prince," with 88 16-c.p. and four 32-c.p. lamps with a direct-coupled plant, and four miners' hand lamps; the "Italian Prince" with 58 16-c.p. lamps and combined plant; the cruiser "Yoshino" was wired for 420 16-c.p. lamps; the "Appomattox" was supplied with combined plant, 116 16-c.p. lamps and 20 32-c.p. lamps; the "Pfalz" with plant and 280 25-c.p. lamps; the "Austrian Prince" with a combined plant of 95 16-c.p. lamps; the "Chickahoming" with a combined plant of 126 16-c.p. lamps; the "Perthshire" with plant and 112 16-c.p. lamps; the "Georgian Prince" with plant and 95 16-c.p. lamps; the "Algoma" with plant; the "Seamew" with plant; the "Trinidad" with combined plant capable of lighting 258 16-c.p. lamps; the "Duffield" with plant and 114 16-c.p. lamps; "No. 221" ship with a plant and 140 16-c.p. lamps; the "Pembrokeshire" with plant and 77 16-c.p. lamps. Besides these, the joiners' shop belonging to Mr. James Laing has been wired and fitted complete with arc lamps; also the Holm Head Dyeworks, belonging to Messrs. Ferguson Bros., were fitted with a belt-driven dynamo, giving 10,500 watts, driven by a vertical engine, lighting 142 incandescent lamps and several arc lamps. Complete Suez Canal plants have been supplied to Messrs. Martin and Co.; a five-unit dynamo with engine has been supplied to the Seamless Steel Boat Company; F. Darling, Esq., of the Eldon Colliery, has been supplied with a pumping plant, which has a special motor pumping 150 gallons per minute; Messrs. Charleton and Co. have been supplied with a belt-driven dynamo for an installation for Mr. Woods, of South Shields, and also with a dynamo for J. Straker, Esq.; while the Wallsend Shipping and Engineering Company have been supplied with dynamos to give 24,000 watts and arc and incandescent lamps, and a somewhat similar plant has been supplied to the Mercantile Dry Dock Company, the dynamo giving 16,000 watts in this case; while to the order of Messrs. Poole and White a dynamo has been supplied to Baron de Rothschild giving 160 amperes at 140 volts pressure.

CROMPTON AND CO. supply us with the following short *résumé* of work carried out during 1893. The work is classified into headings, commencing with what we should call public works for either large corporations or municipal authorities. Prominent among these are the following contracts: Lighting of the Southampton Docks, for the London and South-Western Railway: This work has been carried out on the "low-pressure direct-current system," so as to facilitate the future use of motors, and the lighting at present consists of 60 arc lamps outside, and 1,000 incandescent lamps in the sheds. Lighting of the Great Eastern Railway Company's terminus at Liverpool-street and adjoining premises: The company is now carrying out important extensions in connection with the recent contract, which will increase the number of arc lamps to 200, and the number of incandescents to about 7,000. The work is carried out on the low-pressure direct-current system, the mains consisting in great part of bare copper strip carried on insulators. Bradford Joint-Stock Bank: This consists of 20 warehouse elevators each driven by a separate motor, the supply being off the Bradford mains, each elevator capable of lifting 11cwt. at a speed of 120ft. per minute. Southend Corporation: This is an extension of the former plant, and consists of a second Paxman engine and boiler, additional dynamos, and three additional cars. Crystal Palace: Complete lighting of the main nave, courts, etc., of the Crystal Palace with 90 arc lamps supplied with current from three Crompton dynamos, 500 volts, 30 amperes each, the lamps being 10 in series and three parallel. It is believed that this is the first time that such an arrangement has been carried out, at any rate on such an extended scale. Brighton Corporation: This consists in a set of 45 15-ampere lamps arranged to be supplied off the Corporation's mains, five in series and 230 volts—*i.e.*, 46 volts per arc lamp. Hove Electric Lighting Company,

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Limited: Large extension orders of this company have been carried out both with the bare system of mains and for the permanent plant and buildings now rapidly approaching completion. Dewsbury Corporation: Central-station contract in accordance with the terms recently published, on the direct-current low-pressure system. Compagnie Hydro-Electrique, Antwerp: This is a contract for mains only on bare copper underground system. The present extent of this order is about 13 miles of streets. London and India Joint Dock Company: Thirty-two arc lamps for their new arrangements of lighting at Albert Docks. Southampton Electric Lighting Company: Considerable orders for extension of plant owing to the rapid increase in the output of this company. Hove Commissioners: Complete wiring and fittings for the new Town Hall. In addition to the places included in above list, Messrs. Crompton supplied their new and improved type of arc lamp to the following places: Hull Corporation, for the Market-place (20 lamps); Charing Cross Station (28 lamps); London and North-Western Railway (20 lamps); Glasgow Corporation (80 lamps); Lancaster Corporation: Oxford Electric Lighting Company; Richmond Corporation, through Messrs. Latimer Clark, Muirhead, and Co., Limited; also 30 arc lamps and electrical portion of installation, both for the arc and incandescent lighting of the Batavia Exhibition in Java, through Messrs. J. Birch and Co. Among a large number, the following house installations are the more prominent ones: S. S. Berger, Esq., Knebworth, complete installation of 72 lights, with oil-engine and Crompton-Howell battery; G. Buxton, Esq., Theydon Bois, complete installation of 110 volts, with steam plant and battery; J. H. Tritton, Esq., Lyons Hall, complete installation of 70 lights, with oil-engine and Crompton-Howell battery; Rev. W. A. Duckworth, Frome, 90 additional lights fixed, also generating plant and battery; J. Corbett, Esq., Droitwich, installation of 57 27-plate Crompton-Howell cells, also the lighting of the estate offices. Amongst sundry work not included in the above, the firm have supplied, or have in hand, plants for the complete lighting of steamships for the Société Anonyme John Cockerill; to the Great Eastern Railway; the complete electric lighting of her Majesty's training ship "Worcester"; the Stanton Ironworks Company, for the extension of their new haulage plant; Messrs. Simpson and Co., four sets of plant for lighting pumping stations; the Free Trade Wharf Company; Messrs. Barclay and Fry; Messrs. John Mowlem and Co.; also laboratory installation, consisting of dynamo, battery, etc., to the University College, London. Also they have supplied through their agents, Messrs. J. C. Howell, Limited, of London and Llanelly. and Messrs. Corlett Electrical Engineering Company, of Wigan, a large number of motors for a variety of purposes, but more especially for use in collieries and mines for underground electrical haulage, pumping, ventilating, etc. Also, through their agents (the Crompton Electric Supply Company of Australia), among other plants, the following: Complete installation plant for large business premises in Sydney, consisting of three Davey-Paxman vertical compound "Windsor" engines, coupled direct on the same bed-plate to three dynamos, each having a capacity of 30,000 watts. Complete plant for the lighting of large meat stores at Sydney; pumping plant for a large colliery in Newcastle, the first electrical pumping plant ever installed in the colony; complete central-station plant for the Perth (Western Australia) Gas Company, for the supply of private lighting, together with a complete system of distributing mains through a large portion of the city; additional plant for the *Daily Telegraph* office, Sydney; complete lighting plant for mines, and a large number of other installations.

Doulton and Co., London, have been busy throughout the past year at their well-known Lambeth potteries, and also at their several works in Staffordshire, in the production of pottery for electrical purposes. The high quality of their manufactures has been recognised at the Chicago Exhibition by seven highest awards. This is the largest number granted to any firm of potters in the world, and it is gratifying to know that the honour was secured by a British exhibitor. An important branch of the works at Lambeth is devoted to the manufacture of telegraph and telephone insulators and pottery parts for electrical apparatus in strong vitrified stoneware, and the same articles are produced in porcelain at their Burslem works. During the past few years a new impulse has been given to the manufacture of vitrified stoneware for insulating purposes owing to the adoption of this material as the most suitable, because of its strength and durability, for bare copper electric light mains. Messrs. Doulton have laid themselves out for the supply of such insulators in large quantities, and have designed plant for the manufacture by an improved method which ensures cheapness combined with great strength and high and permanent insulation. During the past year these insulators have been supplied to the Corporations of Oldham, Aberdeen, etc. At the beginning of the year Messrs. Doulton introduced their stoneware underground conduit for insulated electric mains. The conduit is the cheapest system which provides a separate duct for each cable, and it is easily laid, strong, and imperishable. Judging by the way it is being adopted both by London and provincial supply companies, it evidently meets a want and merits the attention of engineers and contractors. Messrs. Doulton are now also offering a stoneware culvert to be used in place of concrete culverts constructed *in situ*. The stoneware culvert is supplied in short lengths, which can be rapidly laid and jointed. We can only give a passing reference to this firm's other productions, such as plumbago crucibles, stoneware apparatus for chemical manufactures, water-filters, etc., which are largely made.

Drake and Gorham.—This firm have had a very rapid increase of work during the past year, for the number of installations carried out reached a total of no less than 150. The installation at Chatsworth for the Duke of Devonshire, carried out by Mr. Drake, the senior partner, of over 850 lights, is, of course, the most important, and in our last issue will be found full particulars, with illustrations of the arrangement of the plant. A few of the other installations are the following: Old Warden, for Major Shuttleworth, steam plant, over 400 lights; Galtee Castle, Abel Buckley, Esq., 150 lights; Hindhead, Miss James, petroleum plant, 80 lights; Brockhampton Court, for Mr. Foster, 130 lights; Major Browne, Callaly Castle, steam plant, 600 lights; Lieutenant Walker Munro, Rhinefield, steam plant, 550 lights; H. O. D. Davidson, Esq., Elmfield, gas-engine, 180 lights; H. F. Tiarks, Esq., Foxbury, gas-engine, 180 lights; A. M. Hallet, Esq., Goddington Hall, petroleum, 150 lights; Lord Cantelupe, Bexhill, gas-engine, 200 lights; Manchester, Liverpool, and District Bank, head office, new plant rearrangement and extensions; Manchester, Liverpool, and District Bank-chambers, adjoining, 120 lights; Richmond sewerage works,

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steam-engine, number of lights equivalent to 105 16-c.p. lights; Reiss Bros., Manchester gas-engine, 200 lights; E. Brook, Esq., Hoddom Castle, gas-engine, 150 lights; Gustav Behrens, Holly Royd, gas-engine, 120 lights. They have arranged for a turbine plant for A. M. Ogston, Esq., Ardoe, the petroleum-engine previously installed by them being used as a stand-by when the water falls short. Among the more important of the wiring are the following: The Great Northern Railway Offices, 650 lights; the Bank of England Head Office, 550 extra lights; the Bank of England, Leeds, 250 lights; the Bank of England, Bristol; the Bank of England, Hull; the Right Hon. Baron H. de Worms, Grosvenor-street, 180 lights; Nicholas Wood, Esq., Lowndes-square, 150 lights; Sir E. H. Carbutt, Hyde Park-gardens, 100 lights; G. Cawston, Esq., Upper Brook-street, 150 lights; A. Spicer, Esq., Lancaster-gate, 130 lights; Union Bank of London, Chancery-lane; Union Bank of London, Holborn-circus; Union Bank of London, Regent-street; they have also remodelled Mr. Rabbits's installation at West Hill, where there are now over 200 lights; the London Brazilian Bank, London; A. G. Sandeman, Esq., Grosvenor-street; Alliance Assurance Office, St. James-street branch, 100 lights; W. H. Spottiswoode, Esq., Sloane-street; Brighton Tennis Court, 100 lights; Manchester and Salford Savings Bank, 150 lights; G. L. Beeforth, Esq., 150 lights; Balliol College, 100 lights; Rock Life Assurance Office, 150 lights; Balliol House, for A. L. Smith, Esq., 50 lights; Westminster School of Medicine; Huth and Co., Tokenhouse-yard, 300 lights; Agnew and Sons, Picture Gallery, 150 lights; W. Boyes, Esq., Scarborough; Sir Guy Campbell, Palace-gate; A. F. Wallace, Esq., Hyde Park; Manchester, Liverpool, and District Bank, King-street, 100 lights; London and River Plate Bank, new premises, Princes-street; Messrs. S. Behrens and Co., Manchester; the Club, Scarborough. During the year they have been compelled to open a permanent branch in Manchester, owing to the amount of work which they had continually in hand in the district. In Scarborough they have also opened a branch, as it was found absolutely necessary to cope with the large number of installations in progress. In fact, the extra work all round has necessitated their adding several offices to their already commodious premises in Victoria-street. The sale of the Cardew earthing device and Cardew voltmeter continues to keep up well, and there is a continual demand for the ring and spring contact switches made under their patents. The sale of the D. P. batteries has more than doubled during the year, and contractors have begun to appreciate the advantages they possess of high rates of discharge combined with great capacity. They have also been entrusted with the rearrangement and reconstruction of the electrical apparatus in the launch "Florentia," the ordinary running speed of which is now 6½ miles an hour, and at recent trials a maximum of nine miles an hour was obtained. They have also fitted up the electric launch "White Wings" for Messrs. Salter Bros., of Oxford, the normal speed of which is 6½ miles an hour.

Ernest Scott and Mountain have during the past year, and particularly the latter end of the year, been extremely busy in their electrical department. During the year they have installed a total of 69 installations in various parts of the country, the total number of incandescent lamps installed in connection with these installations being 13,000. In addition to this they have installed 153 arc lamps of their own manufacture. The total number of dynamos supplied, and not taking into account a large number of orders in hand at the present time, is 137, their average capacity exceeding 200 lights each. They have also been extremely busy in electric transmission of power machinery, and have supplied, and have on order, six large sets of plant. Amongst the most important electric light installations may be mentioned the following: Combined engines and dynamos for the Japanese cruiser "Yoshino," and the Chilian cruiser "Blanco Excalada"; combined engine and dynamo and complete installation for Heckmondwike boot and shoe factory, the installation consisting of 700 incandescent lamps; complete installation for the Gateshead Co-operative Society, consisting of two gas-engines, two dynamos, and about 400 incandescent lamps; complete installation for Seaham Harbour Co-operative Society, with gas-engine and dynamo, and about 200 incandescent lamps; complete installation for Messrs. Chadwick Bros. for lighting of new spinning mill, the plant consisting of three 400-light dynamos, and about 800 incandescent lamps, also complete lighting of new offices, with dynamo, engine, and 200 incandescent lamps; complete electric light installation for Messrs. Jonas Brook and Bros., Huddersfield, plant consisting of two 800-light dynamos and 1,400 incandescent lamps; complete lighting installation for the Leicester Co-operative Society, consisting of gas-engine, dynamo, and 400 lamps; installation for Crossfield, Barrow, and Co., sugar refiners, Liverpool, consisting of two vertical steam-engines, 400-light dynamo and 150-light dynamo, and about 400 lamps; installation for New Craig House Asylum, Edinburgh, consisting of four compound engines of 60 h.p. each, four 400-light dynamos, and about 1,400 incandescent lamps. In addition to the above lighting contracts the firm have in hand the following pumping plants: Complete electric pumping plant for Lothian Coal Company, consisting of three engines of 120 h.p. each, two 60-unit dynamos as generators, two 60-h.p. electric motors, and two sets of pumps, each to deliver 200 gallons of water per minute against a head of 650ft.; electric lighting and pumping plant for the Coltness Iron Company, consisting of three dynamos, electric pumping plant to deliver 100 gallons of water against a head of 150ft. for supplying the colliery and houses with water, complete lighting plant for the colliery, and lighting plant for 34 workmen's cottages; installation for the Edinburgh roperies, consisting of horizontal engine of 80 h.p., dynamo to run 600 lamps, and complete lighting of roperies. During the year the firm have shipped a considerable number of lighting plants, including the plant for the lighting of the Imperial Paper Mills, Calcutta, and a large cotton mill in Calcutta. They have also in hand a contract for two complete sets of train-lighting plant for India. They have also supplied to South Africa a number of dynamos, and have in hand a large electric pumping plant for Johannesburg, and electric lighting plant for a rice factory in China. Amongst important dynamo orders in hand at the moment may be mentioned an order for seven large dynamos for the English War Office, and also orders for dynamos for India.

Electrical Company.—This company, as in former years, have continued their policy in 1893 of not entering into competition with their customers, who are largely composed of installing firms. In the past year they have had the satisfaction of bringing to the front some approved electrical constructions which have met with universal approval,

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among which may be mentioned their Dolivo measuring instruments—viz., ammeters and voltmeters; likewise the handy testing sets for measuring insulation resistance. The new insulating material, "Stabilit," is rapidly being recognised. There is at present in general but a limited demand for electromotors, which must be considered a great pity, as the more frequent adoption of these motors would tend to increase the day load of the central stations, a circumstance eagerly desired by all central-station engineers, as it would not only be a source of great saving to them, but equally so to the users of power. So far, great success has been met with in direct-current motors, both for ventilating and refrigerating purposes. The multiphase motors, which have neither brushes nor commutators, will be put on the market in 1894, and their great advantages for mining and navigation purposes, where sparking is most undesirable, are evident. The competition for lampholders is, of course, very keen, but the company state that they have succeeded in putting on the market a type of holder which has not been found fault with by the keenest of buyers. They have every reason to be proud of the success of the "Luna" arc lamps. Two of the most successful installations of these lamps were carried out by Messrs. Vaughan and Brown at "Old Paris" and at the Agricultural Hall. The former was an installation of 11 of the "Lunas," which behaved splendidly throughout the whole run. The latter was an installation of 42 in series, running off a gas-engine, and the fact that the lamps burned without a single hitch during the Brewers' Exhibition, the Cattle Show, and Stanley Show, speaks for their steadiness and accuracy of construction. A firm going in largely for arc lamps is, of course, bound to meet with much disappointment before central-station engineers consent to adopt any special type. These lamps, it is said, have earned for themselves the most flattering opinions of experts. The fittings department is doing an increasing business, the electroliers, as well as a new series of cheap plain fittings, and likewise the cigar-lighters, having commanded a large sale. With regard to incandescent lamps, the business done in this line has been most satisfactory, and if orders continue as they come in at present, then accordingly it is estimated that the sale per annum will amount to about half a million lamps.

EDMUNDSONS, LIMITED.—Messrs. Edmundsons have during the past year fitted up private installations for at least a dozen large country mansions. In London also they have been busy, and among the many works carried out the most important have been the fitting up the Junior Constitutional Club and the London School Board Offices, over 1,000 lights having been fitted in each of these buildings.

J. K. FAHIE AND SON.—This Dublin firm have been fairly busy during the year in the electrical way, especially in connection with consultation work. Several important installations in various parts of Ireland have been laid down to their specification and under their immediate superintendence, and a number of old installations have either been remodelled or enlarged. A popular addition to electrical literature, in the shape of a handy little book, entitled "House-Lighting by Electricity," by Mr. Angelo Fahie, M.I.E.E. (the junior member of the firm), brought out last winter, has, we understand, just exhausted its first edition.

E. GREEN AND SON state that during the past year the following electric light installations have been supplied with their fuel economisers for heating the feed-water to steam-boilers, and for which they have just been awarded the highest honours at the World's Fair, Chicago: Manchester, Nottingham, Lancaster, Burnley, Kingston-on-Thames, City-road Station (London), Dewsbury, Hampstead, Oldham, Londonderry, Sheffield, Brussels, Portsmouth, and Leeds. This list is sufficient to show the value of the apparatus as a coal saver wherever steam power is used. Numerous contracts are on hand for the coming year at nearly all the stations where the electric light is being introduced.

J. H. HOLMES AND CO.—During the year 1893, Messrs. J. H. Holmes and Co., of Newcastle-upon-Tyne, have built 173 dynamos for various purposes—*e.g.*, the lighting of mills, factories, shops, houses, and ships, power transmission, and electro-deposition of metals. These dynamos vary in size from ½ e.h.p. to upwards of 200 e.h.p., their total combined output being 2,342,335 watts, or expressed in electrical horse-power, 3,141—that is, equivalent to the power required to supply 41,844 lamps of 16 c.p., each taking 56 watts, as against 30,000 last year, or a total of 669,504 c.p., reckoning the same number of watts per candle. Amongst the principal ship installations, of which the total is 50, may be noted those of the "Rappkahannock," 132 lights, the "Shenandoah," 132 lights, and the "Kanawha," 132 lights, all built for the American cattle trade by Messrs. Alex. Stephens and Sons, of Glasgow; the "Hildebrand," 140 lights, built by Messrs. Hall, Russell, and Co., of Aberdeen, for the Booth Steam Shipping Company; the "Namouna," steam-yacht owned by Gordon Bennett, Esq., 112 lights, worked from accumulators. On this yacht there are also electric fans, electric piano, search-light, and small steam-launch plant, including small search-light. It must be remembered that there has been a general depression throughout the ship-building trade all the year, many of the smaller yards having been closed on this account. Last year this firm installed the electric light in 50 steamers—the same number as the present year. The land installations number 95. Among the larger mills were the Rock Cotton Spinning Mill, Ashton-under-Lyne, 560 lights; the Burns Ring Cotton Spinning Mill, Heywood, near Manchester, 600 16-c.p. lamps; the Stockport Ring Cotton Spinning Mill, 790 lights; the Yew Cotton Spinning Mill, Heywood, 898 lights. In each of these mills there are two dynamos, one capable of running all the lights, worked from countershaft off the main mill engines, the other running the pilot lights, and driven by a special engine. This latter is for use when the main engine is stopped, and when a general light is wanted to enable the workpeople to get about the mill in safety. The installation at Messrs. Walker, Reid, and Co.'s works, Dunfermline, consisting of 1,500 lights, supplied by two large dynamos, may also be mentioned. In this mill the lights are arranged in several circuits, entirely separate from one another, so that an accident to one circuit of the installation in no way affects any of the others. The principal development in the productions of this firm during the present year is the new drum-bar armature dynamo. In this machine the armature is, as the name implies, of the drum type. The armature conductors having to take heavy currents are made in the form of laminated copper bars, connected across the ends by means of spiral end connections. The armature cores are built up of thin discs of the best Swedish charcoal iron, insulated from each other with paper; to prevent undue heating, a fan is mounted on the shaft, which forces a current of air through the core. To obtain positive driving of the conductors, notches are cut in the periphery of the core. The magnet limbs are

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made of soft iron or mild steel, and are very massive to obtain a very powerful magnetic field, and so to reduce the speed of the machines. A machine of this type, of 120-unit capacity, was built for the Aluminium Company, Oldbury, near Birmingham; when tested by Prof. Kennedy it gave an efficiency of 98 per cent. Messrs. Holmes have already many orders for 1894. Among these are a Russian emigrant ship, built by Messrs. R. and W. Hawthorn Leslie and Co., 300 lights, and ventilated throughout with electric fans, having a total capacity of 1,000,000 cubic feet of air per hour; two steam-yachts built by Messrs. Ramage and Ferguson, of Leith, one steamship built by Messrs. Harland and Wolff, Limited, Belfast, one by Messrs. Connell and Co., of Glasgow, 130 lights. Of land installations, those of Messrs. Joshua Smith, Limited, of Manchester, 1,100 lights; the Vulcan Spinning Mill, Bury, 1,060 lights; Messrs. J. Pullar and Sons, Perth, 172 lights (a number of arc lights have also been installed here this year by this firm) have recently been put in hand. At present Messrs. Holmes are fitting up four sugar-mill installations in the West Indies, and have just completed one in Nicaragua, and one in Java, while they have an installation to fit up during 1894 in South America. From the foregoing remarks and figures it will be seen that, even though there has been a general depression of trade during the year, Messrs. Holmes have nevertheless turned out more machines and completed more installations than any previous year.

JOHNSON AND PHILLIPS.—The electric lighting branches of this firm have been well maintained, several of them having been exceptionally busy. Contracts for cables, arc lamps, and accumulators have necessitated an unusual amount of overtime to meet the pressure in these departments. Fresh additions to the buildings and machinery have been put in hand, and are now in progress. It will be remembered that in our last year's summary we referred to the Brooks system of mains, which Messrs. Johnson and Phillips were then on the point of completing for the Chatham and Rochester public street lighting. We have now to report the completion of this contract, and to note the successful working which has attended the installation during the past 12 months. The mains comprise about 12 miles of conductor, and are fitted with junction-boxes, house-service and terminal boxes. This liquid system of insulation has the great advantage over all other systems of being practically imperishable. The cables are placed in heavy wrought-iron tubes, which are then filled with a highly-insulating oil and hermetically sealed, thus securing an insulation which, besides being permanent and reliable, is subject to practically no deterioration. The firm guarantees the perfect working of all mains laid by them on this system for several years. The Brockie-Pell lamp still holds an acknowledged leading position. New shops have been fitted up during the year to cope with the ever-increasing business in them. Hull, Blackpool, Bristol, Portsmouth, Londonderry, Oxford, and Burnley are amongst the towns who have now adopted them for street-lighting. Other places where they are to be found are the Imperial Institute, Blackpool Winter Gardens, Woolwich Arsenal, Bute Docks, and the stations of the London and North-Western and Great Northern Railways. The gardens and Forestry Exhibition at Earl's Court were illuminated by means of these lamps. They have also been shipped in large quantities to Russia, South Africa, New Zealand, and other places abroad. The "D. P." storage batteries have this year been selected out of many competitors for use in several London and provincial central stations; and the increased volume of orders for private installations is the best proof of their popularity in this direction. Cables and wires for electric lighting and other purposes have been demanded at such a rate that work day and night has been compulsory at them for a considerable portion of the year. New and commodious shops are now being erected to relieve the strain. The Perry meter, which the firm has taken up during the year, promises to become an important factor in their business. Already large numbers have been made, and the works are equipped with all necessary plant for their manufacture on a large scale. To make a dynamo so self-regulating as to give not more than two volts variation up or down between 55 and 360 amperes, has been one of the tasks undertaken during the year, and the problem has been solved in a very satisfactory manner, three large multipolar machines of this description having been constructed. Other specialities have been a novel motor-alternator set for use at the University College, London, arranged to work either off the public mains or by means of belt power, and a large multipolar steam dynamo for Her Majesty's Military Electrical School, Chatham. The former is so designed as to demonstrate all phases of alternate-current working. The firm's latest and most successful transformer is commanding a very large sale by reason of its unsurpassed qualities of efficiency. The large ones recently made for Bristol are arranged for the three-wire system.

LAURENCE, SCOTT, AND CO. have been exceedingly busy during nearly the whole of the last 12 months, and their works have been taxed to their utmost capacity. They have completely fitted up the Norwich Electricity Company's supply station, and have already had a repeat order for extra plant. The station has several new features; among others, Mr. Scott's patent meter system is adopted, by which it is arranged that supply in the daytime and after eight o'clock at night is charged at half price. The firm hope in the near future to give full particulars of this and other points in the station, and also full particulars and description of the new system of underground mains which is in use at this station, and which is also the invention of Mr. W. H. Scott. It has proved remarkably cheap and convenient, and is giving complete satisfaction. The firm has further been engaged in some large electric transmission of power work, and the ordinary business of the manufacture of dynamos, motors, etc., has also been fairly good.

LIVERPOOL ELECTRIC SUPPLY COMPANY, LIMITED. During the year 1893 the number of lights supplied from the mains of the Liverpool Electric Supply Company has been increased from 20,000 to the equivalent of 25,000 16-c.p. lamps. A new station has been constructed in Lark-lane, Toxteth Park, for the supply of the chief residential district of Liverpool. Among the private installations carried out by the company during the year may be mentioned: Knowsley Hall, for the Earl of Derby; Maer Hall, for F. J. Harrison, Esq.; Haughton Hall, for R. Brocklebank, Esq.

LLOYD AND LLOYD send photographs, from which the accompanying illustrations have been made, which will illustrate the class of work to which they have been devoting attention during the past year. There has been during that time no specially new development of the process, but the works have been running full time the whole year upon

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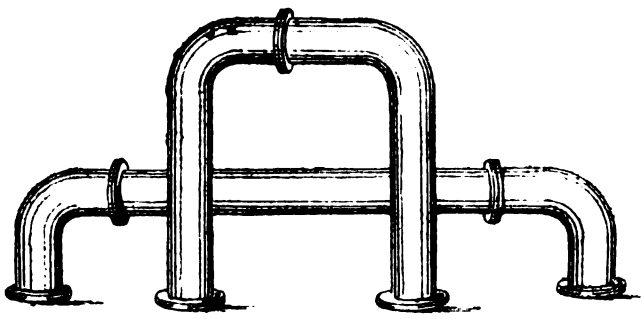
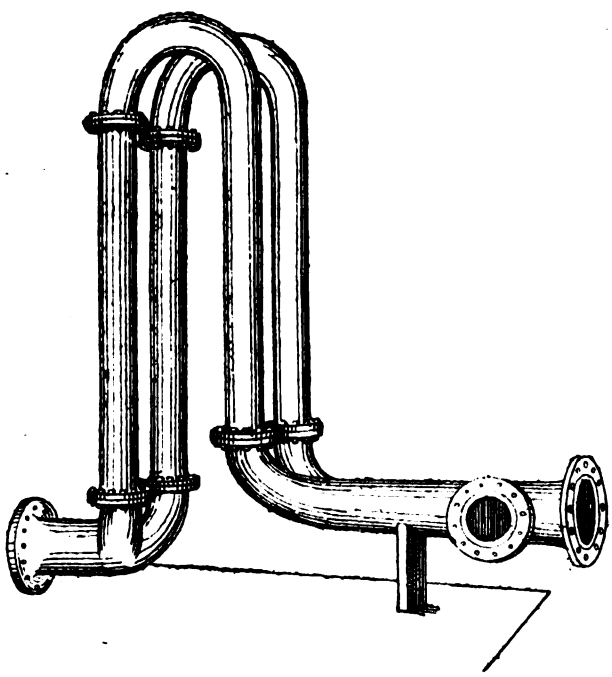
elaborate pieces of work in connection with high-pressure steam installations. We may instance the following as examples: As shown on one of the illustrations, a large expansion piece, 10in. bore,



reduced down to 7in., all in steel ¼in. thick. On the other illustration, the long length having bends reduced from 18in. to 14in. diameter, the other two bends being 15in. diameter; 20in. steel tees ¼in. thick tested to 150lb.; bends, 20in. diameter; tubes 12in. diameter, with four and five outlets 6in. and



8in. diameter; all with flanges solid electrically welded on, tested to 600lb. pressure.

A. P. LUNDBERG has been exceptionally busy during the year, having supplied his various specialities to many of the leading electrical contractors, corporations, railway companies, hotels, etc., and in many cases these fittings have been specified in the contracts for important public and private installations. From the large number of orders in hand there is every prospect of an equally successful 1894. There is a continued good demand for the "Unique" switch introduced in January, 1893, and licensees are working the patent in Great Britain, France, Sweden, Austria, and Hungary. The sale of this speciality in its various sizes and adaptations has exceeded anticipation, the total sale of this type of switch having reached 45,000. There is a very fair export trade to the Continent, United States, and the Colonies. Several novelties are being introduced. These include the "Unique" principle adapted for a "pull" switch and also as a "push" switch, alternate pushes or pulls, as the case may be, making or breaking the circuit; as a double-pole switch, main switch, and adapted for use in a lampholder. The "centric" wall socket, which is another speciality, is also going well, and a new type of double-pole cut-out.

The MANCHESTER EDISON COMPANY give the following list of a few installations which they have carried out during the year: John L. Kennedy and Co., 47, Mosley-street, Manchester; H. Verity and Sons, 47, Mosley-street, Manchester; J. E. Waters and Co., 47, Mosley-street, Manchester; C. Lowe and Co., Chemical Works, Reddish; Sir E. Armitage and Sons, Limited, 48, Mosley-street, Manchester; Thos. Parker and Sons, 18, St. Mary's-gate, Manchester; V. B. Sandford, 33, Booth-street, Manchester; W. H. Vaudrey, Esq., J.P., 9, St. James-square, Manchester; Capes, Dunn, and Pilcher, 8, Clarence-street, Albert-square, Manchester; Geo. Macbeth and Son, 19 and 21, King-street, Manchester; T. Seymour Mead and Co., 7, Piccadilly, Manchester; Jas. Dilworth and Son, Pall-mall, Manchester; Llandudno Pier Company, Llandudno; Guardian Society for Protection of Trade, Manchester; Kendal, Milne, and Co., Deansgate, Manchester; Grundy, Kershaw, and Co., 31, Booth-street, Manchester; W. Crum and Co., 43, Portland-street, Manchester; John Bye and Co., Limited, St. Ann's-square, Manchester; the Temple Chambers Company, Brasenose-street, Manchester; the Liverpool and London and Globe Insurance Company, Manchester; Blackpool Winter Gardens, Blackpool; Horrockses, Crewdson, and Co., Limited, Preston and Manchester; Overseer's Office, 46, Fountain-street, Manchester; Literary Philosophical Society, 46, Fountain-street, Manchester; Royal Insurance Company, 69, King-street, Manchester; Manchester Royal Infirmary, Manchester; E. Butterworth and Co., Waterloo-road, Liverpool; J. H. Gartside and Co., Limited, 56, Fountain-street, Manchester; Murch and Everett, Piccadilly, Manchester; Great and Little Bolton Co-operative Society, Bolton; C. Mortimer Booth and Co., 19, Mosley-street, Manchester; Boarshaw Spinning Mills, Middleton; Princes Theatre of Varieties, Reading; John Ashworth, Broadhalgh Mill, near Rochdale; Jones, Crewdson, and Youatt, Norfolk-street, Manchester; S. and J. Utley, St. James-place, Rochdale; Union Bank of Manchester, Limited, Deansgate, Manchester; S. Albrecht and Co., 16, Aytown-street, Manchester; the Bridgeholme Wadding Manufacturing Company, Limited, Chinley; United States Consulate, 9, Mount-street, Manchester; Myrtle, Burt, and Co., 17, Cooper-street, Manchester; Pendleton Co-operative Society, Limited, Broughton-road, Pendleton; Robert H. Kay, Kay's-chambers, Cooper-street, Manchester; *Co-operative News* Office, 90, Corporation-street, Manchester; Hornblow and Brundrett, 58, Cross-street, Manchester; Manchester Society of Chartered Accountants, Manchester; J. Whittaker, Mount Sion Bleachworks, Radcliffe; Jewsbury, Crux, and Gething, Deansgate, Manchester; W. Hollins and Co., Radford, Nottingham; Addleshaw and Warburton, 15, Norfolk-street, Manchester; Eastern Telegraph Company, Limited, 20, Brown-street, Manchester; A. Thompson and Sons, Low Mills, Rochdale; Albion Hotel, Manchester; P. Moir, Crane, and Co., 6, Bank-street, Manchester; Ashworth, Mosley, and Co., 45, Spring-gardens, Manchester; W. Carwell and Co., 47, Mosley-street, Manchester; Union Bank of Manchester, Norfolk-street, Manchester. The company have also many others in hand.

MANCHESTER ELECTRIC LIGHT INSTALLATION.—Although somewhat late in the day, Manchester has made a fair start toward providing its citizens with the latest form of illuminant in electric lighting.

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Evidence is found of the progress they are making by the condition of the streets through which the mains will pass, and at the same time the motive power and the special apparatus for conducting the current are being prepared. The engines required in generating the electric current are being provided by Galloways, Limited, Manchester. They consist of four distinct compound vertical engines, each having high-pressure cylinder 17in. diameter, low-pressure 34in. diameter, with a stroke of 3ft. The pistons from these cylinders work on to crank-pins placed at each end of a crankshaft, which carries the flywheel acting as a pulley, being turned and crowned for receiving link belt, which transmits the power direct to the dynamo; and, as these dynamos are in close proximity to the engine, jockey pulleys are provided for the purpose of maintaining the requisite tension on the belt. As the engine cranks are at right angles, a receiver between the two cylinders is necessary, and both cylinders, with this receiver, are steam-jacketed—the steam for this jacket being derived from the boilers direct. As is well known, electric lighting requires the most extreme steadiness of turning, in addition to which the speed requires to be varied in accordance with the power the engine is developing. The engines in question are specially adapted to meet these requirements, the variation in speed being effected by Galloways's patent high-speed parabolic governor, specially arranged so that its sensitiveness and speed can be easily altered while the engine is running. The engines are intended to work at a pressure of 120lb. on the square inch, and to develop 400 h.p. each when running at a piston speed of 500ft. per minute. They are also arranged to run faster if required. The steam is condensed, not by the ordinary jet or surface arrangement, but by Korting's ejector condensers placed in close proximity to the engines. These ejectors are supplied from a tank placed over the boiler-house, which will be charged from the canal by means of powerful centrifugal pumps worked by independent engines, the fall of the water condensing the steam, all being carried away without the necessity of an air-pump. The steam required by these engines is furnished by six large boilers, constructed by Galloways, Limited, at their boiler works, Ardwick. These boilers are 30ft. by 8ft., made of steel, to work at 125lb. pressure, and are provided with very complete fittings, including Vicars's mechanical stokers. A very unusual feature in the boiler installation is the duplicated arrangement of the entire ranges of steam and feed pipes; in fact, the duplication is so complete that under no possible combination of circumstances can the whole of the boilers or engines be rendered inoperative. The steam-pipes are of large size, 18in. diameter, and are all of wrought steel, welded with strips double riveted over the weld. These are quite a departure in pipe construction. In addition to the engines as above, Galloways have also made two precisely similar pairs, but of small dimensions, for the Douglas and Laxey Tramway, these engines having cylinders 10in. and 20in. diameter by 1ft. 6in. stroke, with flywheels 9ft. diameter by 12in. wide for taking off the power—namely, 180 h.p. in all. The engines otherwise were exactly similar to those for the Manchester Corporation. The steam for the engines was supplied by two Lancashire boilers 20ft. long by 6ft. diameter of ½in. steel plates, suitable for 125lb. working pressure. The Douglas and Laxey Tramway Company have just let the contract for the continuation of the tramway the whole length, which will require several other pairs of engines similar to those here described.

JAMES MENZIES AND CO.—The wrought-iron tube trade for the past year has been in a very depressed state. Makers generally have been dull, and those who have had much work to do have executed it at an exceedingly low price—if not, indeed, at an actual loss. This being the case, it is somewhat surprising to learn that in spite of this decreased demand for tubes, boiler tubes, and piping of all kinds, either for home or export (the decrease in the latter being confirmed by Board of Trade returns), the firm of James Menzies and Co. actually show an increased production during the last 12 months of about 1,800 tons over the production of the previous 12 months. This is a vast increase in weight, and equal alone to what some of our smaller makers might consider a very considerable production, and shows that this firm will, when trade resumes its usual aspect and our Board of Trade returns their usual increase, take its permanent position as one of the principal, if not the principal, tube-producing firms in the country. They cannot this year trace so much of their demand to tubes for electrical purposes as they could last year, when the City of London Electric Company were in the thick of their work, and were laying down their pipes in such quantities in the City; still, however, a very considerable quantity is being supplied for these purposes, and not the least important are the steel steam-tubes for boiler connections in the new electric stations. Messrs. Menzies report that their Sydney and Melbourne houses are making steady progress, and this notwithstanding the commercial crisis which has existed in these colonies during part of the past year. They find that the tendency on the part of the consumers there is to get as near the source of manufacture as possible, and thus avoid the heavy profits charged by the importer for holding stock against their probable requirements—the consumer in the colonies pays generally, and in wrought-iron tubes particularly has had to pay too heavily for this accommodation. Messrs. Menzies hold fully 150 miles of tubes in stock in their two colonial houses. They report that their home trade has this year increased at a greater ratio than their export trade, and this again is a source of great satisfaction to them, as in the earlier years of this business they acknowledge not having cultivated this branch of their trade as much as they ought to have done.

RONALD A. SCOTT.—The year 1893 has been noteworthy in the annals of the Acton-hill Engineering Works from the fact that they have been, and will in the future be, under the personal management of Mr. Ronald Scott. There has been a steady increase of business, and the orders received have been executed with satisfaction to clients. The switchboard department has been very busy, and has supplied the new type of switchboard to all her Majesty's ships turned out in 1893. A large order for Admiralty projectors and hand-feed search lamps has been executed; also several for the mercantile marine. A large alternating-current projector has been erected on the roof of the Princess's Theatre. This latter work, including the running of 280 yards of heavy cable, was executed in four days. The apparatus for projecting images has been perfected during the past year, and a display was given from the roof of the *Illustrated London News* on the night of the Duke of York's wedding, photographs and names being readily and perfectly projected. The works have also been engaged on orders for heavy water-tight switches and arc lamps. The dynamo department has been exceptionally busy. Amongst others, a large order from the British Government for machines for foreign stations was completed, these

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latter being required to pass very stringent tests before acceptance. It is noteworthy that amongst the dynamos supplied was one for the Princess Soltykoff. Considering the general condition of trade, Mr. Scott has every reason to congratulate himself on his past year's business, as well as upon the fact that extensive orders are now in hand for dynamo and search-light work, which will keep the works busy for some time to come.

PYKE, HARRIS, AND CO., LIMITED, have during the past year supplied a large number of their well-known inductor alternators, among others, to the following institutions, colleges, etc.: Department of Science and Art, South Kensington; City and Guilds of London Institute, South Kensington; Royal Indian Engineering College, Cooper's-hill, Staines; University Colleges at Nottingham, Liverpool, Leeds, and Bangor: Rugby School; W. H. Preece, Esq., General Post Office; Royal Dockyard, Woolwich; Sir David Salomons, Bart.; Lord Blythswood, Renfrew; Telegraph Manufacturing Company, Limited, Helsby, Warrington; Messrs. Rosling and Matthews, Bradford; Messrs. W. T. Glover and Co., Limited, Manchester; the General Electric Company, Limited, London; and E. Andreoli, Esq., London. They have also brought out, in conjunction with Sir David Salomons, Bart., a small closed magnetic circuit transformer, which has had a very large sale, being applicable both for advertising and decorative purposes, as well as having taken the place, to a great extent, of small induction coils. The whole of the experimental work in connection with Sir David Salomons's patent for improvements in electric heating apparatus has also been carried out by them. They have recently constructed a new continuous-current multipolar dynamo, the field magnet of which is of the same enclosed-coil type that the firm are using in their inductor alternators.

TAYLOR, SMITH, AND CO.—This firm have executed during the year 1893 the principal fittings at Bagshot Park, for his Royal Highness the Duke of Connaught; the Merchant Taylors Hall, London; the Vintners' Hall, London; besides a large number of private residences both in England and Scotland.

TELEGRAPH MANUFACTURING COMPANY report that they have been extremely busy in all departments during 1893. Their vulcanised cables have had a large sale, and they have supplied a large quantity of both high and low pressure mains to various contractors for town work. In their instrument factory they have been favoured with large orders from the Postmaster-General, railway companies, etc., and they have found their sales increase in every department.

W. H. WILLCOX AND CO. have during the year had a great increase in business generally, owing to the progress made by the electrical world in connection with the various installations started in the United Kingdom, and the firm claims a fair share of orders in the way of special cylinder and dynamo oils, also all engineers' sundries. They have also taken up the sole agency for the Penberthy patent injector, also the Farringdon patent pump. These were formerly worked by Messrs. Pontifex and Wood, of Shoe-lane, who have given up this department entirely. This has given them a good addition to general trade. They are building a new warehouse, which will be opened early in the New Year, to enable them to hold a large stock of oil, cotton waste, leather belting, indiarubber and asbestos goods, also the various articles required by electric light installations in the way of stores for the engine-room.

The following is a complete list of applications for provisional orders deposited with the Board of Trade up to the 21st of December, 1893, under the provisions of the Electric Lighting Acts, 1882 to 1890:

Title of Order and Description of Area.	Name of Promoters.
Aberdare Electric Lighting Order. A portion of the District of the Aberdare Local Board.	J. C. Howell, Limited.
Barrow-in-Furness Corporation Electric Lighting Order. The Borough of Barrow-in-Furness.	The Corporation.
Bedford Electric Lighting Order. The Municipal Borough of Bedford.	Bedford Electric Light Company, Limited.
Birmingham Electric Light and Power Order. A portion of the City of Birmingham.	Birmingham Electric Supply Company, Limited.
Buxton Electric Lighting Order. The Urban Sanitary District of Buxton.	The Local Board.
Chelmsford Electric Lighting Order. The Borough of Chelmsford.	Crompton and Co., Limited.
Chepping Wycombe Electric Lighting Order. The Municipal Borough of Chepping Wycombe.	The Corporation.
Chesterfield (Corporation) Electric Lighting Order. The Borough of Chesterfield.	The Corporation.
Clonmel (Corporation) Electric Lighting Order. The Borough of Clonmel and portions of the District of the Clonmel Union.	The Corporation.
Collier-Marr Moss Side Electric Lighting Order. The Urban Sanitary District of Moss Side.	Collier-Marr Telephone and Electrical Manufacturing Company, Limited.
Grimsby (Corporation) Electric Lighting Order. The Borough of Grimsby.	The Corporation.
Guildford Electric Lighting Order. The Borough of Guildford.	Holloway Electricity Supply Company, Limited.
Harrow Electric Lighting Order. The Urban Sanitary District of Harrow	The Local Board.
Leyton Local Board Electric Lighting Order. The Local Government District of the Leyton Local Board.	The Local Board.
THE COUNTY OF LONDON.	
Crystal Palace District Electric Lighting Order. Portions of: The District of the Beckenham Local Board. The Borough of Croydon. The Parish of Lambeth. The District of the Lewisham District Board of Works, and the Parish of St. Giles, Camberwell.	Crystal Palace District Electric Supply Company, Limited.
Monmouth Electric Lighting Order. The Municipal Borough of Monmouth.	The Corporation.
Oswestry Electric Lighting Order. The Borough of Oswestry.	Oswestry Electric Lighting and Power Company, Limited.
Peterborough Electric Lighting Order. The Municipal Borough of Peterborough.	The Corporation.
Plymouth Corporation Electric Lighting Order. The Borough of Plymouth.	The Corporation.
St. Austell Electric Lighting Order. The District of the St. Austell Local Board.	Veale and Co., Limited.
St. Helens Corporation Electric Lighting Order. The Borough of St. Helens.	The Corporation.
Shropshire Electric Lighting Order. A portion of the Borough of Shrewsbury.	Shropshire Electric Light and Power Company, Limited.
Stirling Electric Lighting Order. The Royal Burgh of Stirling.	Caledonian Electric Supply Company, Limited.
Wakefield Corporation Electric Lighting Order. The City of Wakefield.	The Corporation.
West Hartlepool Electric Lighting Order. The Municipal Borough of West Hartlepool.	The Corporation.
Yeadon Electric Lighting Order. The Urban Sanitary District of Yeadon.	The Local Board.

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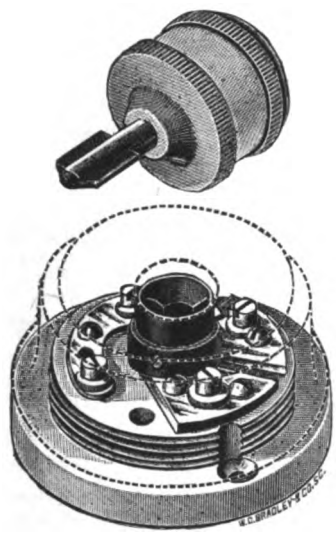
TRADE NOTES AND NOVELTIES.

THE "CENTRIC" WALL SOCKET.

Mr. A. P. Lundberg is putting on the market this wall socket. The plug consists of two segmental rods of spring brass, separated by a backbone of vulcanised fibre running parallel with them, and effectually insulating them from each other; these three component parts are screwed together in the plug, and form a cylinder of ¼in. diameter, with the fibre backbone projecting on each side, the two brass rods forming the contacts of the plug. On the base is screwed two brass contact-plates of ample size, which together form a circular



hole for the reception of the plug. A fibre collar fitting over the projecting ends acts as a shield against short-circuit; a cut-out is also provided. When the plug is inserted, the projecting fibre occupies the space between the contact-plates of the base, and prevents the possibility of any contact being made between them except in the proper manner.

BUSINESS NOTES.

Liverpool Overhead Railway.—The traffic receipts of this railway for the week ending 31st ult. amounted to £619.

Cuba Submarine Telegraph Company.—For the month of December the receipts were £7 more than for the corresponding period of 1892.

Direct Spanish Telegraph Company.—The receipts for the month of December were £197 less than for the corresponding period of 1892.

Ealing.—The Local Government Board have sanctioned the raising by the Ealing Local Board of a loan of £25,000 for electric lighting purposes.

Fined for Assault.—A fine of 10s. has been imposed upon an ingenious individual who a few days ago assaulted an arc lamp trimmer in the City.

West India and Panama Telegraph Company.—The receipts for the two weeks ended December 31 were £143 less than for the corresponding period of 1892.

Western and Brazilian Telegraph Company.—The receipts for the week ended December 22 were £3,446, and for the week ended December 29 were £2,719.

Edinburgh.—The Cleaning and Lighting Committee have resolved to recommend that the line of street from the Tron Church to Jeffrey-street should be lit with the electric light

Hanley.—The Town Council invite tenders for wiring and fittings for the Corporation buildings. Tenders are wanted by the 29th inst. Particulars are given in our advertisement columns.

Brayton Oil-Engine Company, Limited.—This Company has been registered with a capital of £80,000 in £5 shares to acquire certain letters patent for improvements in hydro-carbon engines.

District Messenger Service.—The ordinary general meeting of the District Messenger Service and News Company, Limited, was held on Tuesday at the offices, 50, Lime-street, E.C., Mr. G. Espec J. Manners presiding.

Brighton.—A rental of £25 per annum is to be paid to the Corporation by the directors of the Sea-shore Railway Company. It is proposed to make further additions to the generating plant at the municipal station during the present year.

Compliment to an Electrician.—We note by the Dublin papers that his Excellency the Lord-Lieutenant of Ireland has been pleased to appoint Mr. Angelo Fahie, M.I.E.E., Dublin, to the Commission of the Peace for the city of Dublin.

Treharris.—A public meeting was held on Monday of gas consumers, ratepayers, and others residing in Treharris, when resolutions were passed complaining of the gas supply. Several of the speakers entertained the idea of approaching the Ocean Coal Company to supply the electric light instead of using gas.

Lighting of Newspaper Offices.—The new offices of the Dublin *Daily Express* are lighted by electricity. The engine and dynamo were supplied by Messrs. Edmundson and Son, Capel-street, and the latter is capable of illuminating upwards of 140 lights.

Hull.—The chairman and deputy-chairman of the Sanitary Committee of the Town Council have been appointed to the special committee having under consideration the question of utilising the destructor in connection with the production of electricity.

Messrs. W. T. Glover and Co.—Mr. Henry Edmunds, who since the decease of Mr. W. T. Glover has carried on the business of Messrs. W. T. Glover and Co., of Salford and London, has from the 1st inst. acquired the whole of the business of the Company.

J. G. Statter and Co., Limited.—This Company has been registered with a capital of £20,000 in £10 shares. The object is to acquire as a going concern and carry on the business of electrical and mechanical engineers as hitherto carried on by Mr. J. G. Statter and others at 68, Victoria-street, S.W.

City and South London Railway.—The receipts of the Company for the week ending December 31 were £833, against £966 for the same period last year, or a decrease of £133. The total receipts for the second half-year of 1893 show an increase of £34 over those for the corresponding period of 1892.

Tender Accepted.—The tender has been accepted of Messrs. Cammell and Co., of Sheffield, for the supply and delivery of about 500 tons of steel rails and fishplates, for the Brighton and Rottingdean Sea-shore Electric Tramroad Company, at the price of £4. 2s. 6d. for rails, and at £6. 6s. 9d. per ton for fishplates.

York.—Among the works which will probably engage the attention of the Corporation during the next 12 months, the supply of the electric light takes a foremost place. At the outset the installation will only serve a portion of the centre of the city, but the supply will be extended as required. The estimated cost is £15,000.

Nalder and Harrison.—Mr. N. F. Nalder and Mr. Haydn T. Harrison have entered into partnership for the purpose of carrying on the business hitherto conducted by Mr. N. F. Nalder, and in order to meet the increase of business they are now moving into larger premises at Trafalgar House, Great Newport-street, Charing Cross-road, W.C.

Tenders Invited.—Tenders are invited for lighting and ventilating the police courts at the Salford Town Hall. The plan, specification, and forms of tender may be obtained at the borough engineer's office. Tenders, endorsed "Ventilating Police Courts," must be delivered to Mr. S. Brown, town clerk, Town Hall, Salford, by 11th inst.

Charge of Theft.—On Monday and Tuesday, at the Leeds City Police Court, Mr. Charles Herbert Bent, late manager of the Thomson-Houston Electric Tramway in Leeds, appeared to answer a charge of stealing various sums of money, a suit of clothes, and other articles belonging to the company. Evidence was adduced, and the accused was committed for trial.

Belfast.—The buildings of the central fire brigade station, now completed, comprise engine-house, six-horse stable, hose tower, and dynamo-room on ground floor, etc. The premises are heated by steam and lighted by electricity. The fire-alarms and telephones are received into a test-room at the top of the tower, and conveyed to the indicator in the duty-room.

Manchester.—On Wednesday the Corporation accepted tenders for work connected with the installation of the electric light. It was stated that the mains were to be laid, to begin with, in the thoroughfares from which the largest number of applications for the light had been received. It was expected that some little time would elapse before the installation would pay its way.

Wakefield.—The Corporation, having become dissatisfied with the manner in which the streets have been lighted by the local gas company, recently determined to apply to the Board of Trade for a provisional order authorising them to supply the electric light within the city. The matter has been referred to a committee, who are seeking the necessary information to lay before the Council.

Morley.—The Town Council on Tuesday received the report of the Electric Lighting Committee, which stated that they had carefully considered several schemes sent in for the lighting of the Town Hall and town generally by electricity, and that it was resolved that the committee should be empowered to consult an electrical engineer, and also to visit such electric lighting stations as they deem necessary.

Chichester.—The Lighting Committee of the Town Council a short time ago passed a resolution instructing Messrs. Kincaid, Waller, and Manville to report to the Council as to supplying the city with electric light for a fee of 30 guineas, such fee to be merged in their commission in the event of their employment to carry out the work. This firm is now carrying out the work in a very satisfactory manner.

Dewsbury.—Some time must elapse before the supply of light by the Corporation will be commenced, as although the mains are already laid, the engines, boilers, and dynamos are only now in course of erection. The installation is for the centre of the borough only, and does not include street-lighting. Mr. W. H. Preece is the engineer to the Corporation. The Co-operative Society of Ravensthorpe, near Dewsbury, have decided to introduce the electric light at a cost of £350.

A Joule Fund.—The Mayor of Salford has decided to institute a fund for providing a silver medal annually to commemorate the

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discoveries of the late Dr. James Prescott Joule, to be competed for by students, or those who had been students, of the Salford Technical School, the City of Manchester Technical School, and the students or associates of the Institute of Civil Engineers under the age of 25 years. the medal to be at the disposal of a committee of the corporations in the order mentioned.

Change of Address.—The headquarters of the consulting practice in civil, mechanical, and metallurgical engineering which Mr. Jeremiah Head has hitherto carried on at Queen's-square, Middlesbrough, has been transferred to 47, Victoria-street, Westminster, S.W. The Middlesbrough office will be retained as a branch. Mr. J. Head has taken into partnership his son, Mr. Archibald Potter Head. M.I.Mech.E., who has for some years been his chief assistant. The practice will in future be conducted under the style of Messrs. Jeremiah Head and Son.

Monmouth.—The Town Council on Monday discussed the revised estimates from the Brush Electrical Engineering Company and Mr. Lailey, C E., as required by the Local Government Board. showing the cost of drainage and electric light separately. The figures showed that if the drainage and electric lighting be carried out separately the initial expenditure would be increased to £19,049, or something over £1,000 more than the original estimate for carrying out the combined scheme. The matter was adjourned to a special meeting, which was to be held yesterday.

Robey and Co., Limited.—As mentioned in our last issue, Messrs. Robey and Co. have been registered as a limited company with a capital of £300,000 The first signatories to the memorandum of association are: Mr. F. Andrew, Lincoln; Mr. T. Bell, Lincoln; Mr E. M. Burton, Lincoln; Mr. F. M. Burton, Highfield, Gainsborough; Mr. H. Mackinder, Mere Hall, near Lincoln; Mr. J. Richardson, South Park, Lincoln; Mr. C. Scorer, Coombe Hurst Lincoln. The first directors are Messrs F Andrew, T. Bell, F M. Burton, S. Lowe, H. Mackinder, and J. Richardson.

Southend.—In a review of the year's work of the Town Council, a local paper states that the Pier Committee in February started to consider the provision of additional electrical plant, and pushed on so rapidly as to recommend the acceptance, at the March Council meeting, of Messrs. Crompton's offer at £1,988. In the summer, Mr. H. J. Dowsing (of Messrs. Crompton and Co.) was allowed to utilise the pier current for the running of a launch at 4d. per Board of Trade unit. The year closes with proposals by the committee for the improvement of the tramway so as to secure the comfort of tram passengers

Bolton.—At a meeting on Wednesday of the Town Council, Mr. Broadbent drew attention to the desirableness of constructing subways for the water and gas mains, as well as for the electric lighting cables. At present the streets were being continually taken up to repair the mains or for other purposes of the kind, and he had been surprised to find how large a sum was spent in this work. Alderman Miles, the chairman of the Gas and Lighting Committee, replied that it would necessitate a large expenditure, and though it might be desirable he could not hold out any hope that the work would be undertaken at present.

Wednesbury.—When the question of gas supply and prices was discussed a few days ago, Mr. Oldbury asked if it would not be a favourable time to enquire into the propriety of lighting the public buildings with electricity. The Mayor said a plan had been perfected of putting oxygen into gas, whereby the lighting power of the latter was increased to the extent of 5½ candles; and if that could be generally done a longer life would be given to gas, and the desire for the introduction of electricity would become less prominent Seeing that Huddersfield had adopted the new system, he did not think that Birmingham would be behind.

English-Made Electric Light Carbons.—Hitherto all the electric light carbons consumed in this country have been imported from the Continent and the United States. Now, however, the English Electric Carbon Company, Limited, of the Electric Carbon Works, Brymbo, near Wrexham, have started a factory in that town on the most approved continental lines. The company have determined, for the present at any rate, only to produce carbons of the very highest quality, at least equal to the best continental brands, and they believe that the use by consumers of inferior American qualities of carbon is the cause of the notion in some quarters that an arc lamp can only work by fits and starts.

Coventry.—The Town Council have confirmed the minutes of the General Works Committee, from which it appeared that the town clerk and the city surveyor had attended at the offices of the Board of Trade, and had an interview with Sir Courtenay Boyle and Mr. W. S. Graff Baker and his solicitor. The committee had ordered that subject to Mr. Graff Baker and the Coventry Electric Tramways, Limited, entering into an agreement. that the statement and certificate of cost mentioned in Clause 2 of the agreement of 17th April last, between the Corporation and Mr. Baker, shall take account only of money actually expended on the tramways and their equipment prior to their transfer to the company, the opposition to the transfer be withdrawn.

Traction at Newcastle.—A special meeting of the Tramways Committee of the Newcastle Corporation was held on Wednesday to consider the advisability of issuing to the Council an informatory report on the proposed alteration in the tramway system of Newcastle It may be remembered that in May last Mr. Morton brought forward a motion in the Council that the committee be empowered to enquire into the relative merits of steam, cable, electricity, and other methods of working various tramway systems. The committee, on Wednesday, after fully considering the matter, decided to send a report to the Council, detailing all they have seen, and stating that they are prepared to recommend the adoption of the cable system in Newcastle at an early date.

Epstein Accumulators—The Epstein Accumulator Company, Limited, has just completed the installation of a large battery for the Hunts Bank lighting station of the Lancashire and Yorkshire Railway at Manchester, consisting of 60 of their type R 11 cells, capable of discharging up to 250 amperes. The company are extremely busy with a number of orders for important batteries, amongst which is one of 120 cells, type R 13, up to 270 amperes discharge, for the Lancaster electric lighting station, and another of 54 cells, type R 25, discharge up to 540 amperes, for Messrs. Barclay and Co., Regent-street, as well as a battery of the traction type for the War Office.

Guildford.—The Holloway Electricity Company have received consent from the Town Council to their application to the Board of Trade for a provisional order. The conditions are said to be so unreasonable that unless they are modified, or the Board of Trade dispenses entirely with the consent of the authority, the project will have to be abandoned. The Council ask, in effect, that a clause shall be inserted in the provisional order giving them power, after the expiration of 10 years from the granting of the order, to purchase the undertaking at whatever price the plant might be valued. No allowance is to be made for compulsory purchase or "goodwill," or for the money sunk in preliminary expenses and in placing the undertaking upon a sound footing.

Companies Liquidated or Converted during 1893.—Among the companies that have gone into voluntary liquidation, or have been continued under another form during the past year, are the following: The Telephone Company of Austria, the Electrical Supplies and Fittings Company, and the London Lighting and Engineering Company. The companies wound up voluntarily with a view to reconstruction, amalgamation, or some other form of existence, included the Foreign Electric Date and Time Stamp Company, the Boy Messengers and Electric Call Company, and the Electric Construction Corporation. Elmore's French Patent Copper Depositing Company and the "Medical Battery" Company were ordered to be wound up by order of the Court.

Amalgamation of Engineering Works.—Messrs. John Wilson and Son, of the Vulcan Works, Johnstone, advise us that they have purchased all the patent rights, drawings, patterns, etc., of the late firm of Messrs. J. and W. Weems, hydraulic and general engineers, Perseverance Ironworks, Johnstone. They have also purchased the works, tools, plant, drawings, patterns, etc., of the late firm of Messrs. Wm. Robertson and Co., machine tool makers, Floor-street Works, Johnstone. Messrs. Wilson and Son have combined the two businesses, and will carry same on at the Vulcan Works, Johnstone, executing orders for the various specialities of the two firms; and they have placed these works under the supervision of Mr. Alexander Wylie, who for the past 30 years has been connected with the late firm of Messrs. J. and W. Weems.

Government Contracts and Foreign Labour.—It was recently stated that, though thousands of British workmen were starving in consequence of scarcity of employment, the General Post Office had instructed "Siemens, of Berlin," to put down a cable between Liverpool and New York at a cost of £2,000,000. A letter has been received by a correspondent, who drew Mr. Arnold Morley's attention to the subject. The letter stated that no order for an Atlantic cable had been given by the Post Office Department. The cables between this country and America belong to private companies, and it is understood that one of the companies—viz., the Commercial Cable Company (an American company)—is about to lay an additional cable. The order for this cable has, it is believed, been given to Messrs. Siemens and Co., whose works are at Charlton, near Woolwich.

Halifax.—The Corporation have, in consequence of the electric light supply by a private company having been suspended, been forced to take action in providing electricity works, which is being done under the auspices of the Gasworks Committee. The Corporation applied in August last for the sanction of the Local Government Board to borrow £30,000 for electric lighting. The scheme has been prepared by Mr. Wilmshurst, the Corporation's electrical engineer. The central station is to be at the gasworks. The Corporation will lay mains throughout the principal streets sufficient to supply 30,000 lights. but the plant in the first instance will only provide for 10,000. There will be sub-stations at the Town Hall and in George street, and the cables will be laid under the footpaths. The estimated cost of these works is £26,100, which does not include street-lighting.

Bradford.—A large number of replies have been received by Mr. W. Glossop to his circular, referred to in our issue of the 22nd ult., and addressed to the ratepayers of Heaton, asking if the recipients were in favour of the Bradford Corporation supplying electricity in place of gas at Heaton, which is now served by the Shipley Gas Company. The general effect of the answers is favourable. Mr. Glossop's idea is to get a separate installation for Heaton and Manningham, and he has hope that his object will be attained. He has obtained particulars respecting the price of gas and the electric light since they were introduced into Bradford. The Corporation acquired the works of the old gas company on July 1, 1871, when the price of gas was 3s. The price of electricity on September 20, 1889, when it was first introduced by the Corporation, was 6d. per Board of Trade unit, and the present charge is 5d.

Lighting of Engineering Works.—The shareholders of Messrs. Dixon and Man, Limited, Steel and Wagon Works, Armadale, visited the works last week. The works have recently been almost entirely reconstructed, and the electric light introduced into the engineering, bridge-building, and steel toolmaking departments

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The installations were carried out by Messrs. Walter Dixon and Co., of Glasgow. The plant consists of a Tyne dynamo, constructed to give an output of 7,475 watts, and driven direct by a separate engine. The whole of the works, including the saw mill, machine shop, truck shop, smith's shop, stores and paint shop, together with the offices and the Board-room, are fitted up and lit with incandescent lights of various candle-powers, amounting in all to 66 lamps of 16 c.p. and eight lamps of 50 c.p., and various other groups of lights where most required. In the bridge-building shop and in the yard three arc lamps of 2,000 c.p. have been placed.

Lighting of Co-operative Stores.—The Leicester Co-operative Society have had their extensive premises at the corner of High-street and Union-street fitted with the electric light. Messrs. Scott, Mountain, and Co., of Newcastle-upon-Tyne, have carried out the installation. The plant comprises a Robey gas-engine of 16 brake horse-power, provided with a self-starter and an extra large flywheel and a Tyne 18-unit dynamo. There are 320 lights in the building, which is divided into five circuits. There is a large arc lamp at the top of the building. Near the dynamo-house is a room for the storage cells, of which there are 55. At the formal ceremony in connection with the starting of the installation, the Chairman said that co-operators generally were on the look-out for more light—light to assist them in developing their production, and also in distributing what they produced. They had tried various methods of lighting their premises, but had now arrived at the brightest light—namely, electricity.

Pupils' Dinner.—The past and present pupils connected with the Manchester branch of Woodhouse and Rawson United, Limited, held their first annual dinner on Wednesday, December 20, at the Grosvenor Hotel in that city, when upwards of 20 past and present pupils and friends sat down to dinner. Mr. H. C. Crews, the local electrician, occupied the chair. After dinner the evening was spent in getting through a varied programme of songs, etc., contributed by the following gentlemen: Messrs. Crews, Handford, Dewar, Gardam, Payne, Jackson, Twemlow, Wilkinson, A. B. Pilling, and W. Wilkinson, Messrs. Lea and F. S. Pilling accompanying. During the evening the local manager, Mr. Bertram Thomas (who had been prevented by business from being earlier), put in an appearance and contributed not a little to the enjoyment of the evening, his rendering of a well-known song being greeted on its conclusion by those present singing "For he's a jolly good fellow." In reply Mr. Thomas made a happy little speech, in the course of which he thanked the company for their kindness. Shortly afterwards a most enjoyable evening was brought to a close by singing "Auld Lang Syne."

Birmingham.—The annual conversazione of the Birmingham and Midland Institute will take place on Tuesday, Wednesday, and Thursday next at the Town Hall and the institute. The whole of the rooms used in both buildings for the conversazione will be lighted by the Birmingham Electric Supply Company, who will also arrange in the institute a loan exhibition of electrical appliances. The exhibition will include fittings illustrating the application of electricity to lighting purposes, two rooms being fitted as examples, one as a drawing-room by Messrs. F. and C. Osler, and the other as a dining-room, by Messrs. Evered and Co., Limited A complete set of appliances for cooking and heating purposes will be exhibited, and practical demonstrations will be given by an experienced cook. The apparatus for these purposes will be supplied by Messrs. Crompton and Co. A number of small motors will be shown working in connection with various types of light machinery for manufacturing and domestic purposes The exhibition will also include specimens of various arc and incandescent lamps in general use, measuring instruments, and specimens of the Birmingham Electric Supply Company's system of underground mains. Telephones in connection with public performances in distant towns will be again exhibited by the National Telephone Company, Limited.

Railway Station Lighting.—The Great Northern Railway Company have recently established a system of electric lighting at their goods yards and warehouses at Wellington-street and Wellington Bridge, Leeds. The supply is obtained from the Yorkhouse House-to-House Electricity Company, Whitehall-road, where the pressure of the current generated is 2,000 volts, and is transformed down at a sub-station on the premises of the railway company in Wellington-street, whence, by means of a switchboard, it is distributed throughout the warehouses and goods yards, the cables being run underground through the yards. There are about 30 Brockie-Pell 2 000-c.p. arc lamps. Twenty of these lamps (in hexagonal lanterns) are placed in the yards, and are fixed either on iron columns or on brackets, varying in height from 22ft. to 26ft. Inside the warehouses the lamps are of the same type as those outside, but are covered by opalescent globes, and are suspended from the girders carrying the upper floor. The lower floor of the granary in Wellington-street is lighted by five incandescent lamps of 100 c.p. each. The cable, which is about two miles in length, was supplied by Messrs. Siemens Bros., of Woolwich, and the lamps, lanterns, transformers, etc., by Messrs. Johnson and Phillips, Old Charlton, Kent, the whole being installed by the Great Northern Company's staff. The effect of this installation is to enable the work in the goods yards and warehouses to be carried on with much more expedition, and with greater facility and safety.

Sutton.—The Local Board have considered a report of the General Purposes Committee, who stated that Mr. Cave and other ratepayers would not tender for electric lighting, but that if no tenders were received they would be prepared to take the matter up. The committee recommended that tenders for electric lighting should be advertised for in the form settled by the committee, and that the clerk be instructed to forward to all persons who have applied to the Board as to working the electric light a copy of the advertisement in answer to such applications. The chairman remarked that if they invited the public to tender for certain things they must make themselves tolerably safe with regard to the obligations they should put upon them in the event of their tender being accepted. Mr. Price was in favour of the matter being referred back to the committee to draw up a specification to be approved by the Board. The Chairman said that one important matter would affect all the persons who tendered, and it was whether the local authority would have the streets lighted with electricity. Mr. Overton said that was one of the last things they thought of. Mr. Wellington said that with reference to the period during which the Board transferred their powers, he thought 14 years would be better than 21, but the committee came to the conclusion that no one would tender for less than 21 years. The Board should have the option at the expiration of 21 years and every subsequent seven years to purchase the system of electric lighting. Subsequently the matter was again referred to the committee.

Northern Society of Electrical Engineers.—Some correspondents write: "We are much surprised at the element elected on the council of this society. If it were termed the 'Manchester Society of Electrical Engineers,' instead of the 'Northern,' we could understand it, as by far the greater portion of the council are manufacturers and contractors in the city of Manchester. We look in vain for a railway telegraph engineer, or a Post Office telegraph engineer, or a National Telephone Company's engineer, and therefore the inference is that telegraphy and telephony are branches of electricity too insignificant to be represented on the council, and that there are no electrical engineers in the North of England except those resident in Manchester. The names of those men who have done good electrical service in years gone past are conspicuous by their absence. We look in vain for the names of Fletcher, Langdon, Hampson, Jackson, Stockdale, Hewitt, Clay, Parker, F. F. Bennett, Vaudrey, Doherty, Macfee, and Holmes—men who have been connected with electrical industry for 15 or 20 years past. On the other hand, we are brought face to face with the fact that some of those appointed on the council are not electrical engineers at all, and cannot by any possible exaggeration be termed such. We need hardly say that if this society is to be conducted on these lines, the result will be disaster, as no electrical engineer of repute would care to be a member or to take any part in the proceedings when the concern is presided over and managed by so unrepresentative a body. To say the least, the selection of the council has been too hurried, and time should have elapsed to allow a larger number of members to join, and then the nominations and voting should have taken place. It would also have been a wise course to pursue to have allowed the representatives of purely electric lighting to be represented on the council by six members, the remaining six to be drawn from the capable ranks of the telephone and telegraph engineers. We consider that, to justify its title, members of the council should have been drawn from various towns in the North, and not all, or nearly all, from one town. Manchester, at the outside, should only have two members allowed to sit, Liverpool two, Birmingham two, Leeds, Bradford, Sheffield, Newcastle, Preston, and Bolton one each."

Lighting of Chelmsford.—At the monthly meeting of the Town Council last week, matters relating to the lighting of the borough by electricity were again discussed. It will be remembered that the whole Council, sitting as an open committee, have recently held two meetings for the express object of dealing with and settling these questions, and their report was Wednesday last week brought up by the town clerk. The Mayor proposed, and Councillor Whitmore seconded, the adoption of the first clause of the report, which related to the question of overhead wires, and which proposed to leave the matter entirely in the hands of the Board of Trade. Councillor G. W. Taylor moved the following as an addition to this clause: "But the Council trust the Board of Trade will, as far as practicable, meet the wishes of the electric lighting company in the matter." He said that Mr. J. F. Albright, one of the managing directors of Messrs. Crompton and Co., and Mr. A. H. Pott were invited to attend a meeting of the Lighting Committee, and the committee virtually and tacitly agreed to send a resolution to the Board of Trade assisting Messrs. Crompton and Co. in the matter of allowing certain wires to remain overhead as far as they could. It might be asked what was the *quid pro quo*? It was this. Mr. Albright consented that if the Town Council would pass such a resolution and send it to the Board of Trade they would reduce the price of the electric light to private consumers from 8d. per unit to 6½d., with a discount of a halfpenny for cash payments within a month of the account being delivered. If the Council simply passed a resolution leaving the whole matter to the Board of Trade, they would not be treating Messrs. Crompton and Co. fairly and reasonably in the matter. In honour to Messrs. Crompton and Co., he asked them to agree to the addition he proposed. Councillor Tanner seconded the additional clause. Councillor Britton supported Councillor Taylor's addition, because he thought they should do all possible to ease a firm who had laid down so many thousands of pounds in the borough, especially as the borough had received from it, during a time of severe depression in agriculture, a very great stimulus. On a division the motion for the adoption of the additional clause was lost. The second clause in the committee's report, which related to the renewing of the contract for the lighting of the streets by electricity, was passed without comment. The third and last clause,

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which dealt with Messrs. Crompton and Co.'s application to the Board of Trade for a provisional order, was then considered. After considerable discussion, the recommendation of the committee, as given in our last issue, was carried. Authority was given to the town clerk to give the necessary notices to the Board of Trade and others interested as to the alteration required by the Council in Clause 80 of the provisional order. It was subsequently resolved to instruct the Lighting Committee to consider the advisability of removing the old gas standards.

Glasgow.—On Tuesday, at a meeting of the Clyde Navigation Trust, the minutes of the Committee of Works were submitted. They contained a report by the sub-committee on hydraulic appliances for Cessnock Docks. The committee having visited various ports where there were large installations of hydraulic plant, reported regarding these, and recommended as follows: (1) That the trustees be asked to adopt a scheme of electric lighting for Cessnock Dock. (2) That designs and tenders be taken for an electric power installation sufficient to light the whole dock, and work, say, nine electric cranes—viz., three for each of the three berths on south quay of north basin, the electric light in the first case being supplied to this portion of the dock. If the cranes are successful, then more boilers and dynamos would be added from time to time as more cranes on the remaining quays were required. Should the cranes not be successful, the contractor should be taken bound to remove them completely to make way for hydraulic cranes to be provided by the trustees; but the electric power would remain for the lighting of the dock, and the surplus power could be applied to lighting some of the quays along the river, or for other purposes. The electrical engineers met with are so confident of success that the committee anticipates no difficulty in obtaining a guarantee of the nature indicated, to guard against the cranes proving a failure and being left on the trustees' hands. (3) That a more liberal supply of cranes should be provided than was at first proposed, and that three cargo cranes should be allowed instead of two to each berth devoted to merchandise. (4) That to give contractors an idea of what the requirements may be, so that they may be enabled to make their calculations, it might be assumed that there would be in the portion of the dock to be dealt with 16 berths for merchandise, each requiring three 35cwt. cranes, giving 48 of these cranes; and that the south quay of dock, consisting of five berths, might be devoted to coal and minerals, and be equipped with two 20-ton coaling cranes and nine 5-ton mineral cranes. (5) That the type of movable crane carriage to be adopted should be what may be called the one-leg and one-arm type, consisting of an elevated platform, supported by the leg resting on wheels running on rails laid along cope of quay, and the arm resting on wheels running on rails laid on or under platform for upper floor in case of a two-storey shed, or on rails at level of or under eave of roof in the case of a single-storey shed. Next to a crane placed upon roof of shed, as at Liverpool, this is the arrangement which would give freest scope for traffic and width for laying down a line of rails between cope of quay and front of shed, and is the plan adopted at Hamburg for steam, electric, and hand cranes, at Southampton for the electric cranes, at Bristol at latest two-storey shed, and it can be seen at the James Watt Dock, Greenock. (6) That the ordinary cargo crane to be placed on a carriage of this description should be capable, as above stated, of dealing with maximum loads of, say, 35cwt. Mr. Richmond moved the adoption of the minutes, with the understanding that the report with regard to crane appliances should not be discussed till next meeting. The minutes, on this understanding, were confirmed.

The Utilisation of Town Refuse.—Mr. C. Rawson has written to a Bradford paper on this subject, and in particular to the statements made by Mr. G. Priestley, and to which reference was made in our issue of the 22nd ult. Mr. Priestley had stated that "Bradford refuse will evaporate 4lb. to 5lb. of water from every pound of refuse thrown into Livet's furnaces, which is considered a good result." To this Mr. Rawson replies as follows: "As one who has had a considerable amount of experience in the burning of town's refuse, both in the laboratory and on the large scale, I can fully endorse the statement that such a result is a good one—an exceedingly good one—especially as town's refuse does not theoretically contain so much heating power. I have always believed in the conservation of energy, and that one is unable to destroy or create matter. It would be highly interesting to know how these fundamental principles have been overcome in Livet's steam generator. I could understand the excellent results if 'a little coal tar and smudge' were mixed with the refuse. Town's refuse, as I have recently shown in a paper read before the Society of Chemical Industry at the Yorkshire College, contains a great amount of combustible matter, but it is not likely that any good will be done by overestimating the amount. As Mr. Priestley does not give details of tests requested by a Mr. Leach, perhaps you will allow me to supply a few particulars. I was present when a quantity of refuse, which had been dried in Smithson's apparatus, was used as fuel. The composition of the crude refuse was as follows:

Coarse portion	34·67 per cent.
Fine portion	27·48 ,,
Rags, paper, etc.	5·76 ,,
Metal, glass, pot, etc.	·84 ,,
Water (evaporated in apparatus)	31·25 ,,
	100·00

6,082lb. of the coarse portion, burned in Livet's furnaces, evaporated 17,410lb. of water. One pound, therefore, evaporated 2·86lb., equivalent to 0·99lb. of water, from 1lb. of crude refuse; but on putting the crude wet refuse into the furnaces, heat would be abstracted in driving off the 31 per cent. of water which it contained. From every pound of refuse 0·31lb. of water would have to be evaporated in the furnace without producing any useful work. This quantity must, therefore, be subtracted from the heating power of the dry material. On the other hand, the fine portion (27·48 per cent.) has an evaporative power equal to about one-half of that of the coarse portion. Making both these allowances, I find that 1lb. of crude refuse thrown into Livet's furnaces evaporates 1·06lb. of water. Of course, if we calculate on the amount of combustible matter present the results are very different. The average amount of combustible matter in a considerable number of samples of refuse which I have analysed is 24 per cent. One pound of combustible matter, according to the above figures, has, therefore, an evaporative power of 4·42lb., but in order to obtain this result rather more than 4lb. (not 1lb.) of refuse must be thrown into Livet's furnaces. In the above calculations I have assumed that refuse thrown on to the fire in its crude state would produce proportionately as much heat as when it has been previously dried, but the attainment of such a result is doubtful. However, perhaps Mr. Priestley will furnish details of tests of burning the crude wet refuse. If 4lb. to 5lb. of water can be evaporated from every pound of town's refuse put direct into a boiler furnace provided with movable grate-bars, it seems strange that the problem of dealing economically with the material was not solved long ago. Providing such a result could be obtained, the product after drying would possess a greater heating power than that which is usually obtained from good average coal."

The Tramway Question at Leeds.—On Wednesday, at a meeting of the Town Council, Alderman Sir Edwin Gaunt, on its being proposed that the minutes of the Highway Committee be approved, complained that more information had not been given as to what was being done with respect to the tramways. He was particularly anxious to know what course was to be adopted as to the working of the lines, whether they were to be let to a company or the Corporation intended to carry on the undertaking itself. With respect to the system of traction to be adopted, he was informed that in Birmingham there was a loss of 2¼d. per mile run last year by the electric system, whereas there was a profit of 6d. per mile by the cable system. He should perhaps be told that in the case of the electric system in Birmingham accumulators were used, and that these were wasteful. That was so; but, in his opinion, what they had seen in South Staffordshire would be equally wasteful. In conclusion, Alderman Sir E. Gaunt expressed himself strongly in favour of letting the tramways to a company. Alderman Ward was of opinion that if they could let the tramways upon such favourable terms as had been obtained by the Edinburgh Corporation, there would be no hesitation as to what should be done. He did not think the Corporation should take upon itself the working of the tramways. As to the system of traction the choice seemed to lie between electricity and the cable. With regard to the cable system in Birmingham, which was said to have been so successful, it had to be remembered that in that case there was a three minutes' service in a densely-populated part of the city; whereas, in the case of the electric system, that was only an experimental line, on the accumulator principle, which was now considered "out of court" on account of its heavy cost, and the population of the district was comparatively small. It would obviously be necessary to decide what system of traction they would adopt, before they set about relaying the track. The Highways Committee were fully alive to the importance of the matter, and he undertook to promise that the Council should be taken fully into their confidence. Mr. Loe agreed with Alderman Gaunt. The Corporation had as much on their hands as they could manage. He incidentally observed that he greatly admired the way in which the Roundhay Park electric cars were worked. Alderman Scarr also approved of the lines being let. He was convinced that if the Corporation attempted to manage the tramways, the result would be a fiasco. He hoped they would seek to imitate Edinburgh in the matter. He was persuaded that competition for the tramways of the city would not be lacking. If they could get a rental of £13,000, that would be equal to a rate of 2d. Mr. Battle held that a corporation could not work such a concern as well as a private company. Alderman Firth (chairman of the Highways Committee) replied that it had never been the intention of the Council to take any responsibility with regard to the selection of a system of traction. A sub-committee had simply been appointed to look after the working of the lines until they were in fit condition to be let, and to enquire and recommend as to the best system of traction. Their recommendation would come before the Highways Committee, but the Council would have to finally decide and take the whole of the responsibility. The committee realised the importance of the work, and were doing what they could to serve the city, and he hoped that time would be afforded them to make the necessary investigation. Leeds could show the best specimen of motive power to be found in the country; but whether the citizens would approve of that system being applied to the whole borough was another question. With respect to the Corporation working the tramways, so far as he was at present informed, he should be no party to it. The less labour the Corporation employed the better it would be for the citizens. The course he favoured was to ultimately let the lines to some company that would meet the requirements of the Corporation as to workmen's cars and the service generally, including the working of any extensions that might be deemed necessary from time to time. The minutes of the Highways Committee were approved.

The "Medical Battery" Company, Limited.—The winding-up order against this Company was made last November, and on

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Tuesday Mr. C. J. Stewart, official receiver, issued the usual summary of accounts, together with his observations upon the case. It appears therefrom that in November, 1881, a company with a capital of £15,000 was registered, under the title of the Pall Mall Electric Association, Limited to acquire the business of Mr. C. B. Harness. In March, 1885, the first "Medical Battery" Company, Limited, was incorporated, with a capital of £100,000, to acquire the business of the Pall Mall Electric Association, then carried on at 21, Holborn-viaduct, and a separate business opened by Mr. Harness in 1884 at 205, Regent-street, for the sale of electric and medical appliances. In the year 1889, it being thought advisable to treat patients suffering from various forms of disease, and as the articles of the first "Medical Battery" Company did not provide for such an extension of business, that company was wound up voluntarily, and the new company took over its entire undertaking. The liquidator of the old company was Mr. Harness. Soon after the formation of the Company the lease of the premises terminated, and as the landlord refused to accept the Company as a tenant, Mr. Harness took a fresh lease in his own name, at a rental of £750 per annum, subsequently giving the Company a sub-lease at an annual rental of £1,000. It was resolved to issue debentures for £10,000 in March, 1893, of which £6,000 were offered for subscription to the shareholders, who, however, made at first but small response to the offer. The total issue is £8,150, of which Mr. Harness holds £3,000 and Mr. Graff £1,000. At a general meeting of shareholders on October 14, 1893, it was resolved to increase the capital of the Company to £200,000 by the issue of 20,000 preference shares of £5 each. A prospectus was accordingly published on October 18, 1893, and was advertised in various papers. On the following day and during the ensuing 10 days articles appeared in a London evening paper strongly animadverting upon the Company and Mr. Harness. The advertisement of the prospectus was at once withdrawn, and the money received on application for preference shares was returned. On November 3 it was decided to wind up the Company. By the articles of association Mr. Harness was appointed president and managing director at a salary of £1,000 per annum. At a general meeting of the shareholders on January 22, 1891, it was decided that this sum should be increased to £2,000 per annum. A dividend of 4½ per cent. was paid to the shareholders in 1889, and dividends of 10 per cent. per annum were paid during 1890, 1891, and 1892, the total amount being £34,500. Fees amounting to £1,650 were paid during the same period to the directors. The accounts filed under the winding-up order show total liabilities £23.916, of which £19,780 is expected to rank for dividend. The assets, valued at £4,242, are claimed by the debenture-holders, and the account with the contributories discloses a total deficiency of £119,780. The largest shareholders in the Company are: Mrs. Harness, £38,205; Mr. Harness, £7,225; Major Elers, £14,205; Mrs. Elers, £5,250; and Mr. McRae, £5,000. The deficiency account shows that the trading of the Company resulted in a gross profit of £274,260. and that the expenses of carrying on the business amounted to £240,667. Included in the latter amount is a sum of £170,878 paid for advertising from 1889 to 1893. Law costs (£6,588) appear to have been incurred in respect of the before-mentioned litigation, and a further sum of £861 was expended in experiments directed to prove that the chargee brought by the papers against the Company's appliances were contrary to fact. The failure of the Company is attributed by Mr. Harness to the unfavourable articles and the consequent litigation, also to the later articles in the London evening paper, which induced a number of claims to be made for the return of money paid for goods supplied by the Company, and made it evident that the preference shares would not be taken up by the public.

Electric Lighting in Carlisle.—Very little has been done in this city towards adopting electricity for lighting purposes In the case of public lighting the Corporation obtained a provisional order in 1882 (this order was revoked July 1, 1892) for lighting the town by electricity, but no practical steps were taken under it, although several parties approached the Corporation with a view to get the powers transferred. The Corporation, however, did not see their way either to undertake public lighting by electricity or to assist others in doing so. With regard to private electric lighting, the most noteworthy installation is that in the Public Library, Museum and School of Science and Art Buildings, Tullie House. The buildings are lighted throughout by electricity, gas only being used in part of the basement. The generating plant is situated in the basement in a room specially designed for the purpose. This room contains the engines, dynamos, switchboard, and other necessary appliances, including also one of the water-tanks, while in the meter-room adjoining are placed two 150 light gas-meters and the second water-tank. Adjoining the dynamo-room is a chamber in which are placed the exhaust and silencing boxes for the gas-engines. The plant consists of two Tangye horizontal gas-engines of the most recent type and construction, combining all the latest improvements for electric lighting work. Each engine is of 16 nominal horse-power, and is guaranteed to give 35 actual brake horse-power; they are fitted with Pinkney's patent self-starter, whereby one man is capable of starting an engine. Every precaution has been adopted in order to ensure steady running and to prevent any fluctuation in the lights. With this object in view, in addition to extra heavy flywheels having been provided, the driving pulleys of the engines are made to fit loose on to the shafts, but are connected to the flywheels by means of spiral springs, in order to further deaden the shock due to the explosions in the cylinders. The exhaust from each engine is conducted through specially constructed exhaust silencing-boxes—two to each engine. After passing through these boxes the exhaust gases are conducted by means of two 4½in. internal diameter cast-iron pipes to the roof. Each engine is supplied with a water-tank having a holding capacity of 150 cubic feet for the purpose of circulating water round the cylinder of the engine, and keeping the same sufficiently cool for the purposes of lubrication. Each engine is placed upon and bolted down to a solid bed of cement concrete, 4ft. in depth, so as to ensure a good and firm foundation. The power is transmitted from the engines to the dynamos by means of 6in. strong cotton belting. The dynamos were made and supplied by Messrs. Latimer Clark. Muirhead, and Co, of London. Each dynamo is capable of maintaining 350 16-c.p. incandescent lamps. They are shunt-wound, having an E.M.F. of 105 volts, and giving a current of 200 amperes when running at 600 revolutions per minute. These machines rest on solid beds of concrete 3ft. in depth; to the concrete are bolted three slide rails, and upon these the dynamos rest, being fitted with movable brackets and adjusting bolts for the purpose of tightening up the belt when necessary. The field magnets are wound on separate wrought-iron cores, so that they can easily be removed if necessary. The armatures are interchangeable, and adequate provision is made for ventilation in order to avoid undue heating. There are four copper gauze brushes, having proper provision for adjustment and also for ensuring the necessary amount of pressure when running. The wiring is divided into seven circuits, and is upon the multiple main system—*i.e.*, separate pairs of mains run from the main switch-board to the several parts of the building, where the subsidiary switchboards are placed, and from these latter the wires are taken to the lamps according to the several sub-circuits in each room. All the wires are of copper, tinned and stranded, thoroughly insulated by means of indiarubber, tape-braided. They have been proportioned at a maximum current capacity of 660 amperes per square inch of sectional area, and are laid throughout in grooved wooden casings. The main circuits, sub-circuits, and single lamps or cluster of lamps, are protected in all cases by means of safety fuses proportioned to the current which they have to carry, these fuses in every case being easy of access for purposes of inspection and renovation. The lamps, of which there are altogether some 434, equivalent to 558 of 16 c.p. each, are of the Edison-Swan type, and vary from 8 c.p. to 50 c.p., according to the amount of light required in the different positions in which they are placed. Those of 8 c.p. are used in the subway, cart-dock, lavatories, and in those places where much light is not required, while in rooms where a better light is necessary lamps of 16 c.p., 32 c.p., and 50 c.p. have been fixed. In many instances it has been found advantageous to make clusters of several lamps, of 16 c.p. or 32 c.p. Opal shades of a plain but effective pattern have been used throughout, except in places where the light is required to shine on to some particular object as in the picture galleries, in which case side reflectors have been adopted In the library and main entrances brass electroliers have been fixed which, with their ornamental shades, give a very pretty effect. The main switch-board is placed in a convenient position in the dynamo-room. It is composed of a slate base 1¼in. thick, enamelled on face and fitted in a wooden frame. This slate measures 5ft. by 3ft. On this are fixed the switches to the seven main circuits. On the lower part of this switchboard are fixed the two main switches from the dynamos, and between these principal switches are placed two ammeters. Each switch is composed of brass connecting pieces with vulcanite handles. On this board are also fixed the safety fuses to each of the main circuits, a fuse being placed on both the positive and negative wires The whole of the scheme for the electric lighting of this building has been devised by and carried out under the supervision of Mr. W. Howard-Smith, A.M.I.C.E, city engineer and surveyor. In addition to the installation at the public library buildings, there are three private installations in this city. One is at the works of Messrs. Carr and Co., biscuit manufacturers, and comprises one of Messrs. J. H. Holmes and Co.'s "Castle" dynamos, driven by a H. P. Tangye's steam-engine, and capable of supplying some 300 16-c.p. lamps or their equivalent. The second is at the cotton factory of Messrs. Ferguson Bros., and consists of a steam-engine and dynamo, by Messrs. Clarke, Chapman, and Co., capable of maintaining about 500 c.p. lamps. The third installation is that of Messrs. G. F. Brown and Co., ironmongers, and consists of a 3-h.p. Stockport gas-engine and a "Fawcus-Cowan" dynamo. Some 50 16-c.p. lamps, four 50-c.p. lamps, and one arc lamp of 1,000 c.p. are installed on the premises.

PROVISIONAL PATENTS, 1893.

DECEMBER 18.

24209. **Improvements in elements for secondary and other electric batteries, and in the manufacture of same.** Herbert Frederick Hoveler, 3, Stockwell-avenue, London.

24344. **Improvements in dynamo-electric machines.** John Augustin Kingdon, 28, Southampton-buildings, Chancery-lane, London.

24353. **A new or improved preparation of active material for electric accumulators.** Claude Kennedy Mills, 23, Southampton-buildings, Chancery-lane, London. (Charles Joseph Barbier, France.)

DECEMBER 19.

24389. **Improvements in electrode plates for secondary batteries.** Arthur Lehmann, 70, Wellington-street, Glasgow.

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24392. **Improvements in and connected with electric motors for vehicles.** Charles Frederick Winkler, 70, Market-street, Manchester. (Complete specification.)

24409. **Improvements in or relating to means for conveying electrical currents to the workings of coal and other mines.** Harold Bonser, 323, High Holborn, London.

24414. **An improved means of underground current supply for electric railways.** William Phillips Thompson, 6, Lord-street, Liverpool. (August Rast, Germany.)

24417. **Improvements in electric or galvanic batteries.** Joseph Baxeres Torres, 13, Golden-square, London.

24442. **A new or improved electrical accumulator plate.** Claude Kennedy Mills, 23, Southampton-buildings, Chancery-lane, London. (Charles Joseph Barbier, France.)

24446. **Improvements in electric lamps.** William Allen Phillips, 46, Lincoln's-inn-fields, London (Date applied for under Patents, etc., Act, 1883, sec. 103, June 3, 1893, being date of application in United States.)

DECEMBER 20.

24471. **Improvements in electric supply meters.** William Thomson, Baron Kelvin, 154, St. Vincent-street, Glasgow.

24472. **Apparatus for evaporation, distillation, or concentration of liquids by means of heat produced by an electric current.** James Thomson Bottomley, 154, St. Vincent-street, Glasgow.

24517 **An improved advertising reflector for the top of electric light globes.** Frederick James Mockler, 97, Newgate-street, London.

24557. **Improvements in or relating to electric printing or signalling apparatus.** Andrew Ainslie Common, 45, Southampton-buildings, Chancery-lane, London.

DECEMBER 21.

24606. **Improvements in the means of suspending arc and other electric lamps and fittings.** Ernest Alexander Claremont, 53, Arcade-chambers, St. Mary's-gate, Manchester.

24607. **An improved insulated lever for use in electrical switches and other like appliances.** Ernest Alexander Claremont, 53, Arcade-chambers, St. Mary's-gate, Manchester. (Complete specification.)

24608. **Improvements in the construction of and in the means for fixing flywheels to the pulleys of dynamo-electric motors and generators.** Ernest Alexander Claremont, 53, Arcade-chambers, St. Mary's-gate, Manchester. (Complete specification.)

DECEMBER 22.

24730. **Means for use in combination with conduits or conductors for the supply of gas or other fluid or of electricity for indicating the time during which such gas or other fluid or electricity has been consumed.** Francis George Savage Curtis, 47, Lincoln's-inn-fields, London.

DECEMBER 23.

24736. **Improvements in electric bells.** John Whitaker and Thomas Percival Pollitt, 64, Barton-arcade, Manchester.

24751. **Improvements in safety appliances for use in connection with generating and distributing apparatus for high-pressure electrical currents** John Smith Raworth, 46, Lincoln's-inn-fields, London.

24757. **Certain improvements in electric apparatus for stopping steam or other engines.** William Arnold and William Crowther, Commercial-street, Halifax.

24771. **Improvements in electrical measuring instruments.** Frederik Vilhelm Andersen, 14, Westdown-road, Catford, Kent.

24790. **Improvements in brush-holders for dynamo-electric machines.** Rookes Evelyn Bell Crompton, 55, Chancery-lane, London.

DECEMBER 27.

24864. **Improved methods and means of compounding dynamo-electric machines.** Elihu Thomson, 45, Southampton-buildings, Chancery-lane, London. (Complete specification.)

24865. **Improvements in insulators for electric wires.** Henry Harris Lake, 45, Southampton-buildings, Chancery-lane, London. (William Brisbane Rand, United States.) (Complete specification.)

24867. **Improvements in electric railways.** John Charles Love, and Albert Gallatin Wheeler, 45, Southampton-buildings, Chancery-lane, London. (Complete specification.)

24871. **Improvements in dry batteries.** Harry Torrey Johnson, 323, High Holborn, London. (Complete specification.)

24889. **Improvements in connection with phonographs, graphophones, and similar sound recording and reproducing machines.** Jonathan Lewis Young, 4, Moorfields, Fore-street, London.

24911. **Improvements in electric cables and in the method of making the same.** Thomas Jefferson Dewees, 45, Southampton-buildings, Chancery-lane, London. (Complete specification.)

DECEMBER 28.

24926. **Improvements in the method of and means employed for completing electric circuits.** Walter Brierley, Penny Bank-chambers, Halifax. (Philipp Weber and Johann Heinrich, Germany.) (Complete specification.)

24946. **Improvements in coverings for electric wires.** Franklin Streeter Randall, Edward Packard, John Robinson, and William Julian Chaninel, 28, Southampton-buildings, Chancery-lane, London. (Complete specification.)

24948. **A time electric switch.** Edward Carstensen de Segundo and Walter Derham, 24, Southampton-buildings, Chancery-lane, London. (Complete specification.)

24951. **Improvements in electrical measuring instruments.** Francis Henry Nalder, Herbert Nalder, Charles William Scott Crawley, and Alfred Soames, 16, Red Lion-street, Clerkenwell, London.

DECEMBER 29.

24979. **Improvements in instruments for measuring and recording electric pressures and currents.** William Thomson, Baron Kelvin, 154, St. Vincent-street, Glasgow.

25009. **Electric heater and its application to electric cigar-lighters.** Friedrich Wilhelm Schinder, 433, Strand, London.

25013. **Improvements in or connected with apparatus for feeding carbons in electric arc lamps.** Frederick Hallows and Frederick John Beaumont, 166, Fleet-street, London.

25016. **An improved rosette for electric wires.** Henry Harris Lake, 45, Southampton-buildings, Chancery-lane, London. (William Brisbane Rand, United States.) (Complete specification.)

DECEMBER 30.

25056. **Improvements in incandescent electric lamps.** Francis Lyst, 64, Somerville-road, Hatcham, London.

25082. **Improved means for arranging and intensifying the magnetic fields of dynamo-electric machinery.** James William Thomas Cadett, 33, Southampton-buildings, Chancery-lane, London.

SPECIFICATIONS PUBLISHED.

1887.

1993. **Electrolysing bleaching solution.** Hermite and others. (Second edition.)

1892.

20894*. **Telegraphic or telephonic call system.** Wetzer. (Amended.)

22285. **Microphone transmitters.** Anders and Kottgen.

22422. **Electrical call apparatus.** Khem.

23750. **Secondary batteries.** Hough.

24008. **Electric lamps.** Shepard.

1893.

1354. **Electro-thermal conductors, plates, etc.** Forbes.

1894. **Dynamo-electric generators, etc.** Timmis and Smith.

1902. **Electric conductors.** Mavor and others.

2159. **Electric arc lamps.** Rose.

2167. **Registering telephone calls.** Kahn.

3210. **Primary batteries for miners' lamps.** Maquay.

3274. **Electrical transformers.** Johnson and Phillips.

3402. **Electric meters.** Clark. (Hartmann and Braun.)

4360. **Plates for accumulators.** Thompson. (Société Electric Phœbus.)

8952. **Electric accumulators.** Ellermann.

14910. **Electrolytical deposition.** Jensen. (Sinding-Larsen.) (Second edition.)

16389. **Electric heating apparatus.** McElroy.

18386. **Electrical switches.** Lancaster.

19127. **Printing-telegraph systems.** Linville and Hettmansperger.

19529. **Telephone switch.** Nissl.

19542. **Electrolytical decomposition of salt solutions.** Kellner.

20458. **Electric switch.** De Segundo.

20735. **Lightning conductors.** Ball.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	2⅝
— Pref.	—	2¼
Charing Cross and Strand	—	5
City of London	—	11½
— Pref.	—	13
Electric Construction	—	1⅞
House-to-House	5	2
India Rubber, Gutta Percha & Telegraph Co.	10	22½
Liverpool Electric Supply	5	6½
	3½	4⅝
London Electric Supply	5	1
Metropolitan Electric Supply	—	8
National Telephone	5	4¾
St. James', Pref.	—	8⅛
Swan United	3½	3⅝
Westminster Electric	—	5¼

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NOTES.

Newport.—The County Council have decided to purchase the tramways of the local company.

The Charing Cross-Hampstead Railway.—There will be no opposition on Standing Order proofs to the Bill of this company.

Edinburgh.—The Town Council decided on Tuesday to light the portion of the High-street from the Tron Church to Jeffrey-street by electricity.

Lecture.—A short lecture on "The Discharge of Electricity through Rarefied Gases," was delivered a few days ago by Dr. Riley, D.Sc., at the annual conversazione of the Bradford Technical College.

Stirling.—The Town Council have resolved to refuse their consent to the application of the Caledonian Electric Supply Company for a provisional order to supply the burgh with electric light. The company will, however, proceed with their application.

Towing by Electricity.—A company has been formed in Maryland, U.S., for the purpose of applying electricity on the Chesapeake and Ohio Canal. It is intended to make further experiments on the Erie Canal with boats of which the usual bluff bow and stern will be modified.

Students of the Institution.—A students' meeting of the Institution of Electrical Engineers will be held on Friday next, the 19th inst., at 28, Victoria-street, Westminster. A paper will be read on "Multiphase Currents and their Applications," by Mr. C. V. Drysdale, student.

Telephony Between Belgium and Germany.—Negotiations are proceeding between the German and Belgian authorities with a view to the establishment of a telephone line between Cologne and Aix-la-Chapelle on the German side, and between Verviers and Brussels on the Belgian side.

Royal Institution.—On Tuesday next, January 16, Prof. Charles Stewart will begin a course of nine lectures on "Locomotion and Fixation in Plants and Animals." The Friday evening meetings will begin on January 19, when Prof. Dewar will deliver a discourse on "Scientific Uses of Liquid Air."

Engineers and Shipbuilders.—The fourth general meeting of the present session of the North-East Coast Institution of Engineers and Shipbuilders will take place at the Durham College of Science, Newcastle, on Tuesday next. A paper will be read by Mr. J. R. Fothergill "On Mercantile Marine Engineers."

The Government and Telephony.—It appears there is now no prospect of the agreement between the Government and the National Telephone Company being laid on the table during the present session. Members interested in the subject intend to call urgent attention to the matter at the earliest possible moment next Session.

Morecambe.—The Local Board on Tuesday endorsed a resolution of the Finance Committee protesting against the raising of the price of gas by the gas company from 3s. 11d. to 4s. 2d. per 1,000 cubic feet. It was suggested that the electric light should be adopted, but eventually it was decided to await a reply from the company.

The "Medical Battery" Company, Limited.—The case for the prosecution closed on Wednesday in regard to the charges of conspiracy to defraud brought against Messrs. C. B. Harness, J. M. M'Cully, and C. B. Hollier, in connection with the "Medical Battery" Company. The case for the defence was adjourned.

Utilising Tidal Power.—Another scheme has been advanced for utilising the rise and fall of the tides as motive power. Experiments are reported to have been made with the invention on the coast of Cheshire, where a tidal mill of about 4 h.p. has been used to supply power for driving a dynamo for lighting a house by electricity.

A Charge Dismissed.—A verdict of "Not guilty" was returned on Wednesday at the Quarter Sessions for the city of Leeds in the case brought against Mr. C. H. Bent, late manager of the Roundhay Park Electric Tramway for the Thomson-Houston Company, who was charged in the indictment with falsifying the books of the company with intent to defraud.

Institution of Civil Engineers.—The roll of the Institution of Civil Engineers has lately been increased by the election of five honorary members—the Duke of Devonshire, Dr. Frankland, Sir Douglas Galton, Prof. von Helmholtz, and the Marquis of Salisbury. The number of that class has thus been raised to 20. The gross total of the several classes composing the institution has now reached 6,520.

Royal Meteorological Society.—The annual general meeting of the society will be held at 25, Great George-street, Westminster, on Wednesday at 8.15 p.m., when the report of the council will be read, the election of officers and council for the ensuing year will take place, and the president (Dr. C. Theodore Williams) will deliver an address on "The Climate of Southern California," which will be illustrated by a number of lantern slides. This meeting will be preceded by an ordinary meeting, commencing at 8 p.m.

Lighting at Leeds.—The Yorkshire House-to-House Electricity Company, which commenced to supply the electric light in Leeds last year in certain districts, began business in May with engines of 500 h.p., and engines of 200 h.p. were added some time ago. The directors are now preparing to lay down two additional engines, each of 400 h.p., with the object of both extending the district to be supplied with the electric light and to add further premises on the routes already supplied. They hope in a few months to be able to reduce the cost of the supply.

Personal.—In our issue of December 29th we omitted to state that Mr. Reginald J. Wallis-Jones resigned his appointment with Messrs. Woodhouse and Rawson United, Limited, to join Messrs. Kincaid, Waller, and Manville, the well-known consulting civil and electrical engineers. Mr. James Paxman, who has for many years been the sole proprietor of Messrs. Davey, Paxman, and Co., engineers, Standard Ironworks, Colchester, has taken into partnership his son, Mr. William Paxman, from January 1. The title of the firm remains unchanged.

Electric Traction at Hartlepool.—A joint deputation of the Corporations of the two Hartlepools have visited Leeds at the invitation of Messrs. Sellins and Ashby, the promoters of the project to work the Hartlepool tramways by electric power, to inspect the working of the system there in use. The Mayors of Hartlepool and West Hartlepool headed the respective deputations, which included the borough engineers of both towns. They appeared to be satisfied, by what they saw, with the advantage of the system, upon which they will report to the respective committees.

Society of Arts.—On Wednesday next, at 8 p.m., a paper will be read on "White Lead Substitutes," by Mr. A. Laurie, M.A. On Thursday, at 8.30 p m., a paper will be presented on "The Petroleum Fields of India: thei

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Present Condition and their Probable Future," by Mr. R. D. Oldham, A.R.S.M., Superintendent Geological Survey of India. This meeting will be held at the Imperial Institute, S.W. On February 8, Mr. E. O. Walker, C.I.E., formerly of the Indian Telegraph Department, will read a paper on "Telegraphic Communication between England and India: Its Present Condition and Future Developments."

Telegraphy in Africa.—"It had been hoped in the first months of the year," remarks the *Times*, "that the peaceful strengthening of the links of communication with the north by means of telegraphs and railways would have sufficed to bring about the gradual inclusion of the Matabele nation in the web of mining and agricultural progress. The great scheme for a trans-continental telegraph, which took shape under the initiative of Mr. Rhodes in the early summer, has been so far practically advanced that the line has been surveyed, and material for the construction of the whole section between Salisbury and Zomba, in Nyasaland, has been sent out."

More Gas Explosions.—Two explosions occurred simultaneously on Monday morning, when two manhole covers, one situate at the corner of Creed-lane and Ludgate-hill, and the other in St. Paul's-churchyard, were blown into the air. On Tuesday, at a meeting of the City Commissioners of Sewers, Mr. Ross (in the absence of the engineer) said, in reply to a question, that he had written to Mr. W. H. Preece, and asked for a report on the subject. He had also addressed a communication to the City of London Electric Lighting Company, who had replied stating that the explosion was due to an accumulation of gas in the manholes in question.

A Powerful Lighthouse Light.—The lighthouse on Fire Island, at the entrance to New York Harbour, is about to be provided with plant which will, it is submitted, produce an electric light of 240,000,000 c.p. This tremendous light will be visible from a distance of 24 miles, and in foggy weather from 10 miles, and it is claimed that its reflection on the sky will be seen at a distance of 100 miles. The present light shows for five seconds every minute, but the new light will be visible for five seconds, with dark interval of one second. The present light is visible 16 miles in clear weather. The gigantic lens, 9ft. in diameter, which was exhibited in the French section of the World's Fair at Chicago, has been purchased by the United States Government, and will be used for the new light.

The South Staffordshire Electric Cars.—The paragraph which appeared in various papers stating that a prize of £10,000 is offered to electrical engineers for the introduction of an underground electric system improperly described the overhead system at work on the South Staffordshire Tramway lines. The overhead electric system has been at work on these lines from January 1, 1893, since which time it has run through the principal and crowded streets of Walsall, Wednesbury, and Darlaston, and has given satisfaction to the public, the local authorities, and the company. It is the only system of its kind in existence, the overhead line is on one side of the street only, there are no cross or pull-over wires, and the objectionable features of the American systems are avoided.

He Lost His Character. — The electric light is reported to have caused a man to lose his character. It appears that a clerk to a local board, who is also a solicitor in large practice, got the electric light laid on at his office in a small town in North Wales. Coal, however, fell short, and the light became intermittent. When the clerks were working late on Saturday night they left the switches on, in the hope that the light would presently appear, but they forgot to switch off. The consequence was that when the good people of the town were proceeding to their places of worship on the evening of the Sabbath they found the lawyer's office alight, and, of course, jumped to the conclusion that both he and his clerk were drawing up bills of costs when they ought be contributing to the collections.

Suggested Amendment of the Patent Laws.—The Society of Chemical Industry recently appointed a committee to enquire into the patent laws, with a view to their amendment. This committee has now decided to present a memorial to the Government praying for the appointment of a Royal Commission to enquire into the subject; and the Institution of Civil Engineers, the Society of Arts, the Chartered Institute of Patent Agents, Chambers of Commerce, and other public bodies, are to be asked to join in the memorial. At a meeting of the London section of the society, held at Burlington House, the matter was under discussion, and, among others, resolutions were passed advocating a longer period of protection for inventions than the present 14 years; a preliminary examination of specifications by the Patent Office; the limitation of the power of disclaimer to three years from the date of the patent; the reduction of fees, and the trial of all patent actions by a rota of specially selected judges of the High Court.

Electric Traction at Douglas. — The Douglas Town Commissioners had before them on Wednesday an application on behalf of the Douglas and Laxey Coast Electric Tramway Company, Limited, for a further concession, as from December 6, 1897, of 21 years for the working of the Douglas Bay Tramway. Under ordinary circumstances the tramway undertaking would lapse into the hands of the Commissioners at the first-mentioned date. In consideration of the further concession being granted, the applicants agreed to pay the Commissioners 5 per cent. upon the gross receipts of the tramway from the present time up to December, 1897, and 12 per cent. on the gross receipts from December, 1897, to December, 1918. Many members were of opinion that the town would do well to grant the application; but it was decided to hold the matter over for a fortnight. Several of the applicants attended the meeting and urged the Commissioners strongly to give them a decisive answer at once, as they could not guarantee that the offer would remain open for another fortnight.

An All-British Pacific Cable Needed. — The Dominion Minister of Trade and Commerce states that, although the date of the Canadian-Australasian Conference has not yet been fixed, it will probably be held at Ottawa before the summer. The *Canadian Gazette* remarks that: "Mr. Sandford Fleming had to pay £2. 11s. for a cablegram of two words from Sydney to his family at Ottawa, including a registration fee of 10s. 6d. to ensure delivery of the reply message at his hotel. Can one wonder that with such exorbitant charges the demand for an alternative and all-British Pacific cable is spreading so rapidly among Australian Governments and Australian commercial men? While in Australia, Mr. Fleming made a point of enquiring in the public libraries for a Canadian newspaper. Not a vestige of one, old or new, could he find. What cohesion and stability can an empire have when its leading members are thus isolated from one another? Canada and New South Wales are doing their utmost to put an end to this isolation by encouraging the mail steamship line between Vancouver and Sydney. The Canadian and Australian Colonies are anxious to follow up this effort by an all-British cable. Will the Imperial Government much longer persist in standing aloof and letting her colonies do alone the work of empire?"

Electric Motors on Battleships.—The system of heavy gun mountings and loading gear by Sir Joseph

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Whitworth and Co. was tried the other day on board her Majesty's ship "Centurion," at Portsmouth. The supply of ammunition is arranged in such a way that the guns can be loaded at any angle of training, without coming to a fixed loading station after each discharge. It is intended to fit electromotors to the elevating apparatus, designed for a large angle of fire—viz., minus 7deg., plus 35deg. elevation. The loading station being almost horizontal, the electromotors will be valuable adjuncts to the hand elevating appliances when the guns have to be moved through the angle from loading position to maximum elevation or thereabouts. The motors, however, are merely auxiliaries, as the elevation can be accomplished by the manual gear, though less expeditiously. An electric motor is being fitted to a hoist for rapid transport of the charges to the guns. The sighting arrangements are similar to those in many others of her Majesty's ships, except that, owing to the large angle through which the guns move, special arrangements have had to be adopted to ensure the angular movement of the sight-bars through the extreme range. Each shield has two sighting-hoods, from which either of the guns in the redoubt is trained and elevated, the latter operation being effected by means of an electric switch or by a hand-wheel.

How to Prevent Gas Explosions in Manholes. In connection with the recent explosions of gas in manholes at Glasgow, Manchester, and on Monday in Ludgate-hill, a correspondent to a provincial paper makes the following suggestion: "Prevention is the best cure, and the sooner gas explosions connected with the electric light mains can be prevented the better. On Saturday I noticed that another gas explosion had occurred, but I also noticed, though it may not have been understood by the public, that the cause of the explosion was in no way electrical. Gas had certainly accumulated in the electric light conduit from some leaking gas-pipe in its vicinity, but the cause of the explosion was the approach of a lighted taper for the purpose of examining the mains. Some will say that there should have been no light, or there should have been no spark; and others will say that there should have been no leaking gas, but there are times when these things evidently cannot be prevented. Gas will leak, but we may do something to prevent its accumulation in our electrical conduits. I therefore propose that at every manhole, and at intervals between, escape-pipes be laid down so as to carry any accumulating gas away. These pipes would be laid underneath the pavement slabs, and then up the fronts of buildings, terminating at the top in a suitable cover to prevent rain coming in, but admitting of the escape of gas. At the bottom of this long pipe may be placed a trap to collect and carry away any water that may be deposited by the gas itself."

Rewards for Discoveries and Inventions.—The Committee on Science and the Arts of the Franklin Institute of the State of Pennsylvania desire us to draw attention to the fact that the institute may grant, or recommend the grant of, certain medals for meritorious discoveries and inventions which contribute to the promotion of the arts and manufactures. The character and conditions of these awards are briefly stated in the following: The Elliott Cresson medal, founded in 1848 by the gift of the late Elliott Cresson. This medal is of gold, and by the terms of the deed of trust may be granted for some discovery in the arts and sciences, or for the invention or improvement of some useful machine, or for some new process, or combination of materials in manufactures, or for ingenuity, skill, or perfection in workmanship. The John Scott legacy premium and medal (20dol. and a medal of bronze), awarded by the city of Philadelphia. This is devoted to rewarding ingenious men and women who make useful inventions. The Edward Longstreth medal of merit is of silver, and may be awarded for useful invention, important discovery, and meritorious work in, or contributions to, science or the industrial arts. Further information as to the manner and form in which applications for the investigation of inventions and discoveries should be made will be sent to interested parties on application to Mr. William H. Wahl, secretary of the Franklin Institute, Philadelphia, Pa., U.S.A.

A Peculiar Occurrence at Bournemouth.—A strange occurrence is reported as having happened in this town on Monday. It is stated that as a two-horse 'bus was proceeding along Meydrick-road one of the animals fell down dead, and the other commenced to quiver violently. The driver jumped off, and help arriving, those present soon felt the existence of an electric current. Two dogs passing by suddenly rolled over and yelled furiously, but got away. The presence of electricity is said to have been felt for some distance in the road, and it is supposed that a leakage occurred from the electric light mains underneath the road, and that the horse was probably killed by an electric shock. With regard to this, the Board of Trade, at the request of the Bournemouth Town Council, sent down Major Cardew on Tuesday to enquire into the cause of this accident. The *Standard* states that Major Cardew visited the scene of the occurrence, and had two iron chambers opened near the spot through which the wires pass. Several people stated that on assisting to get the horses up they felt slight shocks like pins and needles pricking them, and a cabman named King told the inspector that he had to leave off helping to unharness the horse, and rub his legs on account of the peculiar sensation which he felt. Others spoke as to seeing dogs jump about and bark and yell on passing near where the horse fell dead. The phenomena ceased when the electric light company cut off the current. Major Cardew had a test battery applied to the wires, but it appeared to reveal no leakage, and at present there appears to be no satisfactory solution of the occurrence.

Boiler Incrustations and Deposits.—Before the Junior Engineering Society, on Friday last, a lecture on this subject was delivered by Prof. Vivian B. Lewes, F.I.C. The lecturer having pointed out the serious injury occasioned to boilers and the waste of fuel due to the formation of incrustations, traced the history of various sources of water supply, and showed how the water acquired the power of forming deposits in steam generators. These deposits consist mainly of calcic carbonate, calcic sulphate, magnesic hydrate, and silica, the chemical processes which lead to their deposition in the feed-water differing in each case. Calcic carbonate, which constitutes the principal ingredient in fresh-water deposits, is thrown down in a dense form by the breaking up of soluble calcic bicarbonate under the influence of heat, and if it is nearly pure it forms a mud in the boiler, which can to a great extent be got rid of by blowing off. Calcic sulphate, however, is deposited by an entirely different action, as its solubility decreases with rise of temperature, high pressure, or great increase in the saline properties of the solution; and its wonderful power of hardening deposits and binding them together into an incrustation, which can only be removed by the use of hammer and chisel, makes it a most dangerous constituent of such deposits. This hardening power is due to the fact that it deposits from water in the form of small angular crystals, and in this form gets mixed with the calcic carbonate mud. As these crystals become heated they lose water of crystallisation, and change their form into fine needle-shaped crystals, which bind the mass

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together. Examples were given of scales from various waters, and it was shown that fresh-water incrustations may be looked upon as consisting chiefly of impure calcic carbonate, whilst the deposit formed by the use of sea-water is principally calcic sulphate. Brackish waters give incrustations consisting of nearly equal portions of these substances. The question of oily deposits on plates was next considered, and the lecturer pointed out that according to recent researches mere wiping of a boiler plate with a greasy rag causes a serious diminution in its power of transmitting heat, whilst with an oily deposit $\frac{1}{16}$in. in thickness, plates in some cases became so overheated as to be unable to withstand the pressure upon them, and collapse of the furnace crowns sometimes ensued. The question of anti-incrustators was then dealt with, and the lecturer expressed his opinion that if manufacturers were obliged to use a hard water, the most reasonable method they could adopt was to soften it on a large scale before putting it into the boiler, as otherwise serious complications would arise in the boiler itself.

The Electro-Harmonic Society.—The next smoking concert of this society will take place on Friday, the 26th inst., at the St. James's Hall Restaurant, Regent-street, W., commencing at eight o'clock. The following is the programme—Artistes: The Dilettante Vocal Quartette; Mr. James Brown; Mr. Edward Dalzell; Mr. Fred. Bevan; Mr. Robert Hilton; harpist, Mr. G. T. Miles; pianist, Mr. Alfred E. Izard; recitations, Mr. I. K. Boddy; humorous songs, Mr. J. Kift; musical directors, Messrs. T. E. Gatehouse and Alfred E. Izard (a Blüthner Aliquot concert grand piano will be used). Programme—Part 1: Part song, "The Hunt is Up" (Hatton), the Dilettante Vocal Quartette; air, "Sombre Woods" (Lully, 1684), Mr. Robert Hilton; harp solo, "Winter" (Thomas), Mr. G. T. Miles; quartette, "The Young Lover" (Koschat), the Dilettante Vocal Quartette; recitation, "The Siege of Lucknow" (Tennyson), Mr. I. K. Boddy; pianoforte solo, "Caprice in E" (Paganini-Schumann), Mr. Alfred E. Izard; new song, "Thy Heart's Rest" (Bevan), Mr. Frederick Bevan; humorous song, Mr. James Kift. Part II.: Glee, "L'ape e la Serpe" (Spofforth), the Dilettante Vocal Quartette; air, "Where e'er You Walk" (Handel), Mr. E. Dalzell; harp solo, "Love's Fascination" (Welsh air), Mr. G. T. Miles; catch, "Would You Know my Celia's Charms" (S. Webbe), the Dilettante Vocal Quartette; recitation, "The Charity Dinner" (Moseley), Mr. I. K. Boddy; song, "I'm a Roamer" (Mendelssohn), Mr. Robert Hilton; part song, "Good Night Beloved" (Hatton), the Dilettante Vocal Quartette; humorous song, Mr. James Kift.

The Use of Wind Power.—In the course of an article on this subject, the *Pall Mall Gazette* says: "Recent discovery has plainly shown that rapidly-oscillating currents send out waves exactly similar to light-waves, but having a much greater wave length. Attempts have been made to get alternate-current machinery of such frequency as to send out such waves. If these are practically successful, light will be generated with much less expenditure of energy, and windmills of very moderate power will be quite sufficient to produce the necessary electric currents. And windmills have been used for the purpose in several places. Prof. James Blyth has been successful in removing many of the difficulties in the way of utilising the wind. He was the first to make trial of the windmill at Marykirk, in Scotland. He first adopted the English type of windmill having four arms and canvas sails. But the sails were too easily torn during a head wind—the very time they were most required. Next he used the American type, having a number of arms and blades of cast iron. But his best form very nearly satisfies all requisites—namely, to be always ready to go, to go without attendance, and to go through the wildest gale. To four strong arms, each about 26ft. long, he attached semi-cylindrical boxes, the opening of each box being 10ft. by 6ft. The vertical shaft is a long rod of iron 5in. in diameter. At the lower end it carries a massive pit wheel which actuates a train of gearing, and drives a flywheel 6ft. in diameter. With a fair wind speed it gives 4 e.h.p., and it works very satisfactorily in a strong gale. Even in that form windmills can be used for lighting lighthouses, which are always on exposed situations, where wind is plentiful, and often in such out-of-the-way places that stores of coal for generating the electric light in any other way could only be sent with difficulty. The large windmill at the two lighthouses on Cap de la Heve, near Havre, has been working satisfactorily. They may also be used for the lighting of private country mansions and factories, especially when these are in sufficiently exposed situations. But if the method suggested by Prof. Blyth be ultimately successful to provide the light by rapidly-oscillating currents, windmills of very moderate power will be sufficient. And the time may not be so very far distant when each house will have its own little windmill storing currents, which may be used to drive the alternate-current machines required in the production of light. Thus from a comparatively cold source light may be produced suitable for each house; and wind, as well as water, can be employed to give the light which is draining away so much of the coal supplies." The last two sentences, to say the least, express too sanguine a view of the subject.

English-Made Carbons for Electric Lighting.—It is a matter for regret that all the carbons used in England for arc lighting have hitherto been imported from abroad. The best quality, which must be used to attain the best results in this system of lighting, come from the Continent, while the inferior quality, used with much less satisfactory results, are an American product. The recent success of the arc light as a high-class illuminant has only been attained by the use of the superior continental carbons—a cored positive and a solid negative being used with a continuous current, both rods being cored with the alternating current. Unfortunately, solid positive carbons, often of poor quality, are still used to a large extent, and it is in these cases that the unsatisfactory burning of the lamps leads many to think still that the arc light is necessarily at times a dark light and always an unsteady light. Under the title of the English Electric Carbon Company, Limited, as mentioned in our last issue, a company has been formed to enter commercially into the manufacture of electric light carbons. The chairman of the company is Mr. John H. Darby, the managing director of the Brymbo Steel Company, Limited; and amongst the directors are Sir H. B. Robertson and Mr. J. C. Edwards, of Ruabon. The secretary and manager is Mr. T. Graham Littleboy, an electrical engineer whose connection with electric lighting will enable him to appreciate the necessities of carbon consumers. The factory has been erected at Brymbo, in North Wales, on the most modern lines, equipped with special machinery and appliances, and is now in full operation. The company have secured the rights to all the trade secrets and methods of manufacture of one of the best carbon-makers on the Continent. A laboratory and testing-room are provided, and the utmost care is used in the selection and treatment of materials and the testing of the carbons. By this means the good quality of the carbons produced will be regularly maintained. At present, only the very best quality carbons are manufac-

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tured, and an exhaustive series of tests of those carbons in comparison with the best continental brands by experts who are very well known, show the company, we are informed, that they have good reason to be satisfied with the quality of their carbons, which in one set of tests were reported as burning "the best." As a consequence, they are sanguine of securing the orders for carbons which have hitherto gone abroad. The registered trade-mark of the company is "Phœbus," and under this name the carbons are being placed on the market. The company have forwarded us a copy of their price-list of carbons ranging in diameter from 8mm. ($\frac{5}{16}$in.) to 20mm. ($\frac{25}{32}$in.). Other sizes are, of course, made. There is no doubt that electrical engineers and consumers of carbons will give this endeavour to start this industry in England on a practical scale every encouragement and assistance.

Electric Haulage in Mines.—A system of electric haulage has been introduced in the mines of the Brock Coal Company, Scranton, Pa. The seam of coal worked averages about 31in. thick, but in some places it is as much as 42in. thick. The present production of the four drifts ranges from 300 to 400 tons per day. The inclination of the seam is very slight, being merely enough to ensure natural drainage for about 5in. in 100ft. The seam has a hard sandstone top and a soft fireclay bottom. It was desirable to have a substantial, economical, and convenient system of haulage suitable for a track laid with light rails running in headings or gangways where mule haulage was impossible, unless excessively large quantities of the fireclay bottom were taken up. Electric haulage was deemed the best for the existing conditions, and the contract for the two locomotives and the entire plant was given the General Electric Company. The success of the electric haulage in meeting and overcoming the difficulties was such as to win for the system the highest endorsement from the officials of the Brock Coal Company. Two locomotives are used, each of the same type and capacity. These locomotives are known as T. M. M., with a capacity of 1,500lb. draw-bar pull each. They are each of the following dimensions: 32in. high, 48in. wide and 9ft. 6in. long. The wheels are 30in. and the axles $3\frac{3}{8}$in. in diameter. The wheel base, which is rigid, is 42in. Each locomotive weighs about $4\frac{1}{4}$ tons, and has two motors of the new iron-clad street-railway type equipped with four-pole Gramme toothed ring armatures. The armatures are series connected so as to use only two brushes each, and these are on the upper side of the commutator and in an easily accessible position. The armatures are connected with the axles by machine-cut single-reduction gears running in gear cases filled with oil. The frames are of cast steel and of such shape as to thoroughly protect the spools and armatures, which are thoroughly waterproofed. The trolley arms are supplied with universal joints, so that they accommodate themselves to any position required by the location of the trolley wire. The feeder is insulated copper wire of No. 00 B. & S. gauge, and the trolley wire is a bare copper wire of No. 0 B. & S. gauge. The feeder wire runs from the power-house across the tracks to a point on the hillside above the tracks, and thence to No. 5 drift. The trolley wire runs along the upper side and close to the track. The power is supplied to the locomotives from a Thomson-Houston D 40-220 volt generator run by an old-style McEwen engine of about 80 h.p. Dynamometer tests made on one of the locomotives showed a steady draw-bar pull of 2,700lb., or nearly 100 per cent. overload. The locomotive is very compact, and is low enough to run in much smaller headings than those at the Brock mine. It is conveniently arranged, so that the motorman can control it perfectly without leaving his seat. On the surface the trolley wire is suspended at a uniform height and distance from the rail. This is also the case in the mine, as far as possible, but it is not always practicable, and a special trolley arm is therefore required.

Science in 1893.—The *Times* of Wednesday contains a long review of science in 1893. We abstract the following concerning chemistry and physics: Some of the most interesting work of the year has been done at the Royal Institution, where, with the aid of new and powerful machinery, Prof. Dewar has produced liquid air in the large quantities required for purposes of research. Thus armed with the means of studying the behaviour of bodies at very low temperatures, he has carried out, in conjunction with Prof. Fleming, an extensive and laborious series of investigations upon the electrical conductivity and resistance of metals at various temperatures down to 200deg. below zero. The results point to the total disappearance of resistance in pure metals at the zero of absolute temperature. In the domain of applied science one of the most noticeable features of the year is the steady extension of the employment of electricity for effecting direct decompositions, hitherto brought about by more circuitous methods. The production of sodium and aluminium, for example, has been immensely cheapened, and the electrolysis of brine threatens to become a formidable rival to the older modes of obtaining alkali and bleaching powder. But the obvious advantages of electrolytic processes will not suffice to ensure their adoption on a really extensive scale so long as electricity has to be obtained through the steam-engine. What is indispensable is a more direct utilisation of natural forces, and it is to this object that inventive talent may now be most hopefully applied. We may not improbably witness in the near future a considerable displacement of industries in order to secure reasonable proximity to water power. Lord Armstrong many years ago led the way in the production of electric light by means of previously unconsidered water power, and his example has since found many imitators. From this point it is easy to advance to the production of electricity upon a great scale for industrial purposes, and countries possessing available resources of the kind required may compete on favourable terms with the possessors of an abundant coal supply. The artificial production of diamonds has been frequently attempted, and success has more than once been claimed. It has, however, been reserved for M. Moissan to solve the problem by crystallising carbon under enormous pressure from solution in cast iron. Carborundum, a substance of hardness scarcely, if at all, inferior to that of the diamond itself, has been before the world for some time, and was used two years ago by M. Tesla to cover the terminals in some of his experiments with high-frequency currents. Its composition and mode of manufacture are now made known. It is a carbide of silicon, produced by subjecting a mixture of carbon and silica to the intense heat of an electric furnace. It has been successfully used to polish diamonds, and will undoubtedly find extensive employment in the arts. Ordinary emery or corundum, in the form of the emery-wheel, is now among the most efficient of labour-saving agencies in our workshops, but is far surpassed in hardness by the new material. In metallurgy, among the more important work, may be mentioned the continued researches of M. Moissan, who, aided by the electrical furnace, has reduced to the metallic state certain refractory oxides, such as those of chromium, uranium, and calcium, obtaining both the pure metals and carbides of the metals. Prof. Roberts-Austen's lengthy investigations on the effects of impurities on masses of metal have yielded results of scientific interest, and have also enabled him to settle several disputed questions of much industrial importance, especially to engineers.

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CRANES AND CRABS.

(Concluded from page 11.)

A very similar type of crane to that last mentioned has been designed by Messrs. W. Sellers and Co., the well-known Philadelphia machine-tool makers and engineers, for the Niagara Falls power-house; but of course the size and capacity are much greater. The span of Messrs. Sellers's crane is 60ft.; maximum load, 50 tons; maximum hoist, 164ft.; speed of lift, from 5ft. to 10ft. per minute (proportionally smaller loads being raised at speeds of 20ft. and 40ft. per minute).

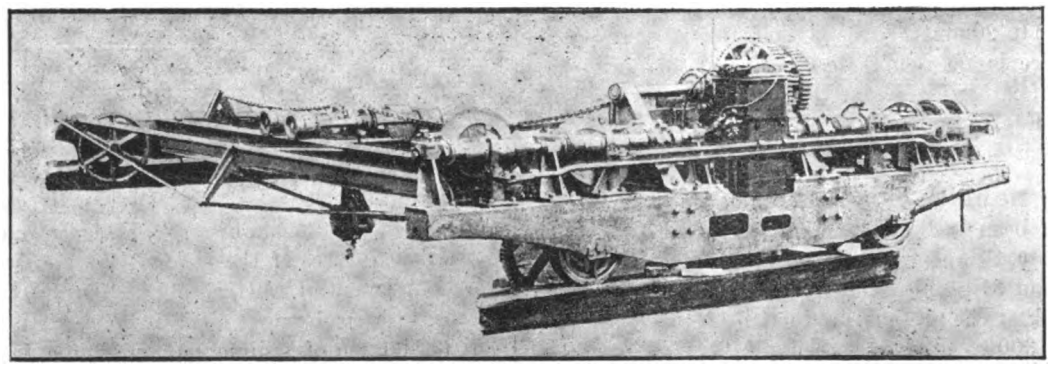

FIG. 1.—Two-ton Crane. Bushbury Works.

The cross traverse can be made either at 50ft. or 100ft. per minute, whilst the longitudinal traverse may also vary, being either 100ft. or 200ft. per minute.

All these motions are worked by means of friction clutches from a constant-speed electric motor having a capacity equal to about 45 h.p., and connected by a belt with a first motion shaft. A framework, or housing, fastened to the side of the crane girders, is made to carry three sets of friction clutches on parallel shafts, which operate spur wheels running loose upon the shaft. The latter, which gear together, receive their motion from the pulley through another clutch shaft connected with the pulley shaft by gears of two ratios, thus providing a fast or slow movement for the whole train. An idler, or an intermediate shaft, is employed to reverse the motion of one set of clutch gears. By this arrangement it will be seen that the clutch wheels on any shaft are run in opposite directions, and that by engaging one or the other of the clutches the shaft may be made to rotate in either direction desired; thus, without reversing the motor, which runs continuously in the same direction at the same speed, any motion of the crane can be effected in either direction and at a variety of speeds. These three operating clutch shafts are coupled respectively by suitable trains of gearing to the bridge travelling mechanism, the travelling crab, and to the hoisting chain.

In this case, as in most others where the same type of crane is employed, practically the whole of the gearing may be carried at one end. The hoisting is done through a long horizontal shaft and bevel gear, parallel with the crane bridge girders, whilst the crab traverse is usually effected by means of a chain or wire ropes wound and unwound upon a geared barrel or drum at one end of the crane.

There is a very complete and well-designed set of small single-motor cranes at the Bushbury works of the Electric Construction Company, and we append two illustrations which will serve to show these, perhaps, more clearly than by words alone. The Bushbury works are notable for other reasons also: as an instance, all the machine tools in the various shops are driven by electric motors without the intervention of any countershafting. Of course a supply of electric energy is available for all these motors from one large dynamo-machine driven by the works engine, and hence the matter of crane equipment becomes very easy and straightforward, no special generating plant being required.

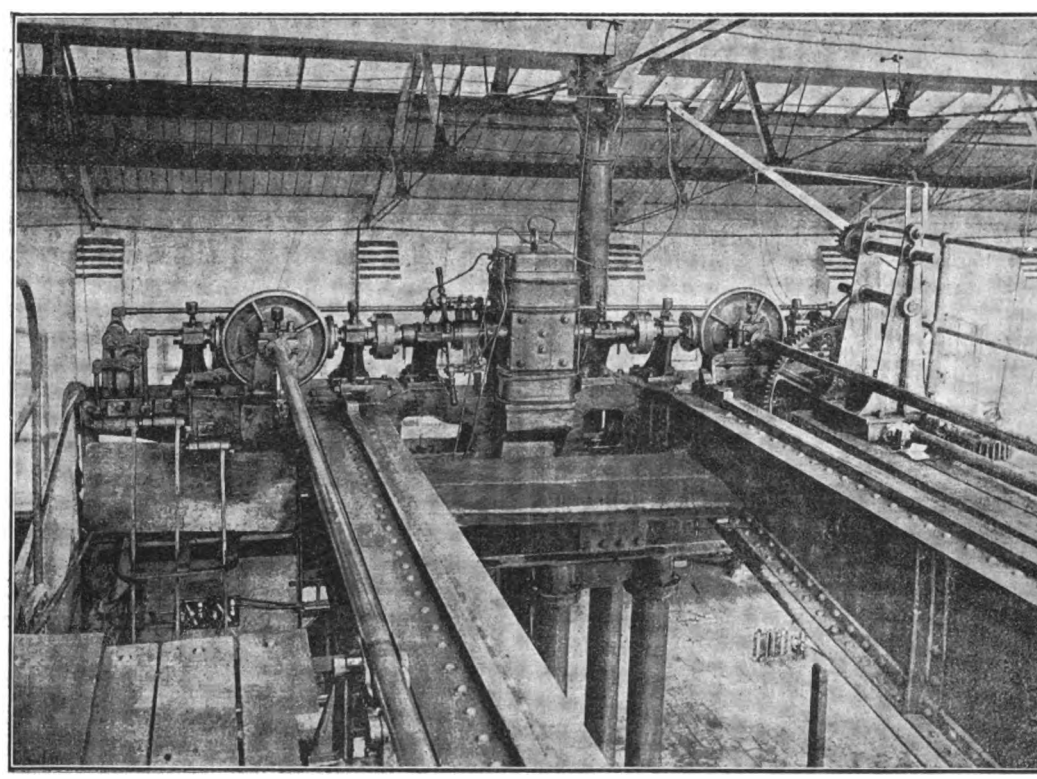

FIG. 2.—Ten-ton Crane. Bushbury Works.

Of the Bushbury cranes illustrated herewith, the small

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one has a capacity of two tons, and is operated by a shunt-wound motor running in one direction only at 900 revolutions per minute. The motion of the armature spindle (which is extended almost the full depth of crane frame) is communicated by means of friction clutches to a geared shaft for the longitudinal travel, and to a somewhat similar arrangement for the cross traverse, which is done by winding up a chain in either direction upon a drum at the motor end of crane. The hoisting chain is carried from another drum or geared barrel, worked by the motor through friction clutches, to a pulley on the crab, passing thence to the crane hook, and back again upwards over another pulley on the crab, the end being finally secured in the usual way to a bracket on the far end of the crane frame.

The second illustration shows a 10-ton crane in the Bushbury works erecting shop; this is very similar in most respects to that already described, and the engraving brings out pretty clearly the arrangement of lengthened armature spindle with friction gear operating the different motions. It also shows the travelling contact by which the current required to work the motor is obtained. This consists of a bare wire attached by means of insulators to the tie-rods or other parts of the roof structure, and connection is maintained through a metal slipper or slide-piece flared out at the ends and pressing upwards against the underside of the wire. The slipper itself is carried at the end of a wooden pole attached to the crane frame, with a flexible wire connection to the motor.

The latter machine is also shunt wound as in the small cranes, and similarly runs at a speed of 900 revolutions.

Arrangement of a different kind to this becomes necessary when three motors are employed, instead of one only, to operate the several movements. The long shafting required to drive the hoist gear, and the chain or wire ropes for the cross traverse, are avoided altogether in such a case, a travelling contact alone being wanted to convey current to the crab and traverse motors.

The illustration, Fig. 3, shows a crane of the three-motor type, with a hoisting capacity of 30 tons. The three motors employed are respectively 3 h.p. for the cross traverse, 10 h.p. for hoisting, and 10 h.p. for the longitudinal travel. A large number of combinations in direction and speed are given, as each motor is provided with a separate controller. The pressure of current used is 220 volts, and travelling contact between crane and the source of supply is kept up with two trolley wires running one on either side of the crane on insulators, copper brushes attached to the ends of the framework lifting the wires as they pass along, just as do the grips of cable tramcars. The motors on the crab receive current through carbon brushes, which slide along copper strips placed on the inside of the frame. The total longitudinal travel of the crane is 165ft., and the span about 27ft. The extreme height of lift is 21ft. 6in. This crane was designed and manufactured by the Morgan Engineering Company, the electric motors being of Thomson-Houston make. One final item of interest regarding the crane is the "solenoid" brake, which holds the hoisting gear automatically as soon as the current is cut off from the motor.

The well-known Oerlikon Works, of Zurich, have, however, with their customary enterprise, travelled still further in the direction of three-motor crane design, and have gone so far as to introduce triphase motors for this work. Fig. 4 represents an overhead travelling crane of this type, erected at the Oerlikon factory, and used there for ordinary works purposes. As in the last example, the travelling contacts by which the necessary currents are supplied to the motors, take the form of grips picking up the conductor wires, which are supported by insulators. Better contact, it is thought, is thus secured, owing to the possibility of dust lying on the top of the wires, and causing sparks if attempts should be made to take off current by a top contact.

The triphase motors are stated to run very easily and without the least trouble: they have, of course, no brushes or commutators, the only wearing parts being the bearings, which are provided with automatic oil-cups.

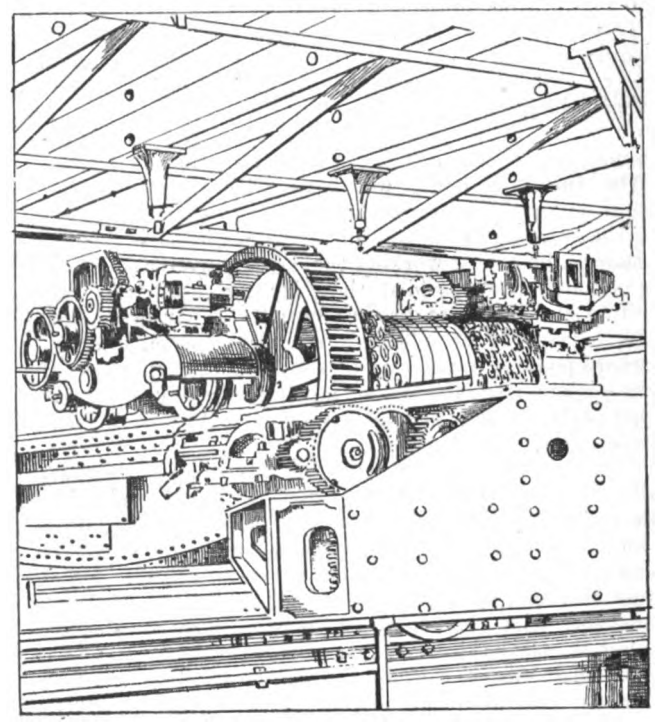

FIG. 3.—Thirty-ton Crane.

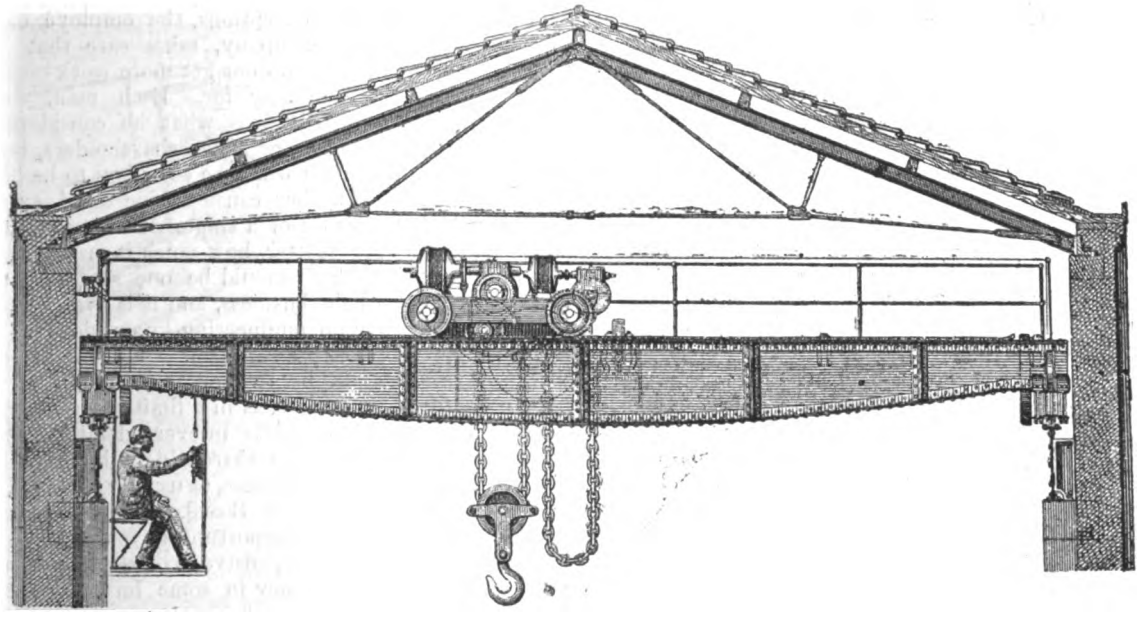

FIG. 4.—Crane with Triphase Motors.

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Speed reduction is obtained by means of worm gear. The worm in each case is of high-quality steel, tempered and ground. The worm wheels are of phosphor bronze, with ball bearings; and the whole gear of each motor is boxed up so that it may run in oil. The other gears—on the crab, for instance—are of cast steel, with double helical teeth.

Fig. 4 is reproduced from the pages of *Le Genie Civil*, and Fig. 3 from *Cassier's Magazine*.

Instances of this type of crane are (as will have been already noticed from the references to the three-motor electric cranes at Crewe works) by no means uncommon; indeed, the question of one *versus* three-motor cranes can only be said at the present time to have just come up for discussion. It certainly is not yet by any means decided.

On the one hand, we have, with three motors, a better adaptation of each to the amount of energy required for the separate crane movements—that is, as in the last instance, the motor working the cross traverse need only be of small power, whilst those for the hoist and longitudinal travel are of greater output. They may, therefore, be worked at a higher electrical efficiency than is perhaps possible in the case of a single motor operating the whole crane, since the latter must necessarily be of sufficient power to effect at least any two, if not all three, of the crane movements.

Thus, in the 30-ton crane last described, it might be advisable to work the two traverses or travel and lift at the same time, and that would involve the use of at least a 15-h.p. or 20-h.p. motor. In any case, one of 10 h.p. would be required as a minimum for the heavy work, and for the cross traverse, where only a small amount of energy is consumed, such a motor might not work quite so efficiently at less than one-third load as at full output.

In small cranes, say, up to a capacity of 10 tons, it is, however, very doubtful whether any electrical economy is secured by the use of three motors instead of one. The powers required for the separate movements approximate more nearly to one another in proportion than they do with heavy cranes to lift, say, 30 or 50 tons. In consequence, the saving of a few per cents. in the motor efficiency is not of great weight in view of the extra complications of three motors instead of one; besides which a 6-h.p. or 8-h.p. motor may, if well and carefully designed, actually give as high an efficiency at quarter load as can be obtained from one of only 1½ h.p. to 2 h.p. at full load.

Of course the gearing incidental to speed reduction is the same in either case, but a slight disadvantage must certainly be debited to the single-motor crane by reason of the friction clutches, with the shafting and other gear required to operate the cross travel and hoisting, and which must undoubtedly cause some amount of mechanical power loss.

The whole question will be found to depend very largely upon cost of power—*i.e.*, working expenses *v.* initial outlay or first cost. A slight saving due to higher electrical efficiencies may be obtained from the use of three motors, at any rate, in large-powered cranes, but the capital outlay would be greater.

Perhaps at present the only conclusion to which we can reasonably point as being credible is that already alluded to—viz., that for small powers the single motor under ordinary conditions will serve every required purpose with most satisfaction. For heavy cranes it will be found best to employ distinct motors of suitable sizes, each worked at full load.

ELECTRICAL ENGINEERING AND LIMITED LIABILITY.

BY S. F. WALKER.

In the present article the writer proposes to discuss the question whether the adoption of the limited liability principle, the formation of limited liability companies, conduces to the advancement of the best interests of those who are engaged in the business or profession of electrical engineering. In the writer's opinion, the result of the adoption of the limited liability principle is very rarely of advantage to electrical engineers generally, and still more rarely to those who are connected with the particular concern which adopts limited liability, and should only be adopted where unavoidable.

In the first place, the expenses of all limited companies are greater than those of private firms doing the same work. They are obliged, necessarily, and for the protection of their shareholders, to work on certain lines in many of the details of their business that entail considerably more expense than would be necessary if the concern was not in the form of a limited company. In the second place, the capital account of a limited liability company is nearly always very largely in excess of that of a private firm doing the same work, while the actual working capital—the earning power—is often less than it should be notwithstanding the inflation. Promotion-money must be paid in some form or other; and usually it is paid partly in cash and partly in shares, the cash payment to the promoter reducing the working capital, while his shares swell the amount on which a dividend must be paid, if one is earned.

Company-promoting is unfortunately, though almost necessarily, a business in itself. Men engaged in the ordinary work of electrical engineering have rarely the time to hunt up men with capital, nor to do all that is implied in persuading them to take shares, and so this work is in the hands of a few men who have, or are supposed to have, a *clientèle* behind them ready to provide money for concerns their guide considers sound. But their guide's idea of soundness is too often formed solely on the view as to whether he and his friends can get anything out of the company, irrespective of the other shareholders. Can the company be made to run for a sufficient time to enable himself and his friends to unload at a profit, and to pocket something substantial in the way of remuneration for work they are supposed to have done? After this has been accomplished, it will perhaps be as well for the company to wind up, in order to make way for a fresh deal on the part of the promoter and his friends.

Another cause of the increased expense involved in carrying on business under the limited liability principle is the fact that the staff of a limited company have rarely the same interest in their work, or at least in carrying the work out economically. Each member of the staff, though he may also be a shareholder, naturally tries to obtain as high a salary as possible. The salary is a certainty, while the dividends depend upon many independent variables. Equally also, with few exceptions, the employé, even the director of a limited company, takes care that his co-employers or co-directors do not get more work out of him than he considers they pay for. Each man, with few exceptions, conscientiously does what he considers to be his duty to his employers, or his co-shareholders, but each man also religiously does what he considers to be his duty towards himself. Another cause of increased expense is the unavoidable absence of a single directing mind. For engineering work, no matter how much it may be divided, it is necessary that there should be one single mind over all, directing the whole business, and it is even better that this mind shall have no engineering knowledge or ability at all, provided that it possesses sound commercial ability, than that there should be two or three minds all taking part in the direction; where, as in a limited company, every director has a right to meddle in every detail, and thinks he is doing his duty to the shareholders by meddling to the utmost of his ability. Where, as usually happens, everything has to come before the Board, time at least is lost, if nothing else. Valuable opportunities too, are frequently wasted, temporary and expensive makeshifts resorted to, and so on; all costing money in some form or the other, and all coming out of the profits.

In every branch of engineering, in every manufacturing business, but particularly in electrical engineering, there are times when very important decisions have to be made, often in a few minutes. Often these cases are such as could hardly have been foreseen, yet must be dealt with immediately. There is no time to call the Board together—someone must act. In a private concern, with only one partner, or with only one active partner, who has the whole details of the business at his fingers' ends, the decision is made promptly, after the few minutes' rapid thought that long experience has enabled him to act upon; and

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the judgment, whatever it is, will be the best possible under all the circumstances—the one calculated to do his firm the greatest amount of good at the minimum of expense. With a limited company, in such cases the manager or managing director, unless he is a very strong man, is terribly handicapped by the fact that he will have to justify his action to his Board. If the matter turns out well, it *may* be all right. But some men are never satisfied even with the most brilliant results. They always have some tale of some friend of theirs who did better under what they consider similar circumstances. They never do any brilliant things themselves, though they are always of opinion that under proper conditions, just such as those referred to, they would have come out wonderfully. It is always their luck never to get the chances other fellows do. Given one of these men on a Board, if he is not effectually muzzled by his co-directors, and not the ablest engineer or manager that ever existed could possibly show a profit.

It will be understood, of course, that the writer by no means wishes it to be inferred that it is impossible to run a limited liability company, doing electrical engineering work, at a profit. Some concerns—such as the large electric lighting supply companies and the large manufacturing companies—must be worked as limited companies, simply because it would be impossible to attract the necessary capital in any other way. But it will be found that even these are successful just in proportion as they are carried on more and more nearly as private concerns. It will be found, without a single exception, that in those large concerns which are successful as limited companies, the power is left entirely in the hands of a very small group of able men—the smaller the number the group consists of, the better. When sufficient confidence is placed in one able man, the concern, no matter what may be its magnitude, invariably thrives best; though even the ablest of men make slips, head and eyes become tired, wrong calculations are occasionally made; yet the cost of even the great blunders of able men under such condition is far less than would be the cost of running the concern with a large number of hands on the reins.

There are a few cases, too, where even small limited companies may be run successfully. There will be cases, of course, where several men, or women, would have sufficient confidence in a man to risk a small sum, provided that they cannot possibly be made to pay more than they originally promise, and this can only be arranged on the limited liability principle. It must be borne in mind, however, that the risks of failure owing to the adoption of limited liability are in inverse proportion, other things being the same, to the size of the concern; and that it is more than ever necessary, in small limited companies, that one man should be absolute. Large concerns may thrive fairly, in spite of imperfect management, owing to outside interest exerted in favour of their companies by the very directors who are a source of expense. With small limited companies, such profitable arrangements are seldom obtainable.

There is one class of cases that should be alluded to that legitimately and naturally come under the limited liability principle. When an industrial concern has grown up from very small beginnings, in the hands of one or two families, after the original founders die, it often happens that shares in the business are possessed by members or connections of the two families, who would much rather have the cash represented by their shares. The ladies of the family, for instance, may have married men in other businesses or professions, to whom the lump sums represented by their wives' shares would be of far more service at the moment than the half-yearly dividend. Their shares are locked up in machinery, factory buildings, stock, goodwill, etc., and are not easily converted into cash. By the adoption of the limited liability principle their shares are immediately marketable.

The writer's object in the above is to endeavour to persuade young electrical engineers who are in business on their own account, and who perhaps find it hard to make a profit, not to rush into limited liability. If it is hard to make a small concern pay in the hands of one or two men putting their heads and hearts into the work with all the energy they possess, it will be impossible to make it pay as a limited company. If your business hardly pays, or does not pay, in your own hands, it is honestly worth nothing; and if you weight it with the additional capital necessary to form it into a company, and with the additional expenses, it can only go under. You may obtain a salary for a short time as managing director, and you may, if you have been very fortunate, obtain a little additional capital to play with; but it is almost an impossibility for you to obtain the capital you require, on terms other than ruinous, by turning your business into a company. Remember, too, that for every five pounds subscribed, for any five or ten pounds, at any rate, you have obtained a new taskmaster, and a hard one—possibly the agent or friend of a rival.

But the way in which the adoption of the limited liability principle has prejudicially affected the advance of electrical industries is by the cutting of prices that has been done by some limited companies, often accompanied by bad work. The necessity of keeping afloat has led them to take contracts at less than cost, and then to raise debentures on the strength of these contracts—which, of course, debenture-holders could not tell would be unprofitable. The result has been, in many cases, that the advance of electrical engineering has been retarded, because distrust has been created in the stability of the work; and in addition, everyone connected with the concern, many not connected with it, and often the whole industry, have lost heavily through the lowering of prices that ensued.

FAULTS IN DYNAMOS.

Mr. J. A. Montpelier has contributed several articles to our contemporary *L'Electricien* on this subject, an abstract of which may prove interesting. The author points out that the faults which affect the working of a central station may occur in the dynamo, in the distributing system, in the house wiring and fittings so far as the electrical part is concerned, or may occur in the prime motor. Only the faults which may affect the dynamo are considered. These are:

1. The dynamo gives no current.
2. Great sparking at the brushes.
3. Abnormal heating of some of the constituent parts of the dynamo.
4. The dynamo is too noisy and too shaky during running.
5. The armature runs too slowly.

We will examine, he says, in their order the various causes of these faults, the methods by which they may be detected, and the means by which they may be remedied.

In the case of a dynamo giving no current the fault would be due to one of the following causes:

A. Remanent magnetism in the field too feeble.

B. Defective contacts.

C. Short-circuit or bad insulation in the internal or external circuits.
- (*a*) Badly-insulated terminals.
- (*b*) „ „ brush-holder.
- (*c*) „ „ armature coils.
- (*d*) Short-circuit in the armature coils.
- (*e*) Short-circuit on the commutator.
- (*f*) Short-circuit at some point of the wiring.

D. Open circuit in the dynamo or external circuit.
- (*a*) Disconnection in the field coils.
- (*b*) „ „ internal circuit.
- (*c*) Brush not making contact.
- (*d*) Disconnection in the external circuit.

E. Reversed field-magnet coils.

With regard to A—that is, weak residual magnetism in the field—the fault is easy to detect by means of a small piece of iron held towards one of the poles, when the iron is but slightly attracted. Usually, the causes of the fault are many. It may be due to a reverse current in the field-magnet coils—such, for instance, as would result from the accidental discharge of a battery of accumulators with reversed connections, the action of terrestrial magnetism,

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or the disturbing influence of another dynamo in close proximity to the first. To remedy this fault, the dynamo must be separately excited. If the defect continues, pass a second but reversed current through the field-magnet coils.

When the dynamo is series wound it is sufficient to start it, and when it has attained its normal speed to short-circuit it momentarily by connecting its terminals with a copper wire. As soon as excitation begins the short-circuiting wire must be removed, to avoid risk of damage to the machine.

When the dynamo is shunt wound another method must be resorted to, because excitation cannot be produced by short-circuiting. In this case remove the external circuit, excite as before, and replace external circuit.

B. DEFECTIVE CONTACTS.—Bad contacts in the different connections on a dynamo are only to be discovered by a close and careful examination in detail of every connection of the armature and coils, and an equally careful cleaning of the various parts. When the fault is caused by a defective contact in one or more of the fixed coils it may be detected by approaching (without contact) a piece of iron to the pole-pieces. If the contacts are good, the iron will be equally attracted by each pole-piece; but if bad, the magnetism will vary, and the movement of the iron held in the hand enable the fault to be located.

C. SHORT-CIRCUIT OR BAD INSULATION IN THE INTERNAL OR EXTERNAL CIRCUITS.—This fault is indicated in shunt-wound dynamos by a feeble but still perceptible magnetisation of the pole-pieces. To ascertain whether short-circuit exists in the internal or external circuit, the conductors should be removed from the terminals of the dynamo, and an incandescent lamp substituted for them. If the lamp burns steadily, the fault must be in the external circuit. If thenot, fault can be located in the internal circuit by the following tests:

(*a*) *Badly-Insulated Terminals.* — Insulation of the terminals should be tested by means of a battery and

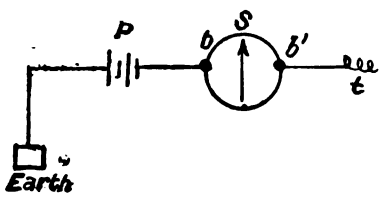

FIG. 1.

galvanometer. The battery, P, Fig. 1, is composed of three or four Leclanché cells connected in series. One of the poles of the battery is put to earth—through a gas or water pipe, for example—and the other pole is connected to one of the terminals, *b*, of a galvanometer, G. The other terminal, b^1, is connected to a loose wire, whose other extremity is successively brought into contact with each terminal of the dynamo. If the insulation is good, the needle of the galvanometer should not move. The insulation of each terminal may be found by connecting the earth lead of the battery with the base-plate of the dynamo, and then touching successively each terminal with the wire from b^1.

(*b*) *Badly-Insulated Brush-holder.*—The procedure is the same as in the foregoing test, each of the brush-holders being touched in succession with the wire from b^1.

(*c*) *Badly-Insulated Armature Coils.*—The insulation of the armature coils is ascertained in the same manner, but great care must first be taken to detach the outer wires, so as to be sure that the fault is not in the external circuit. When the armature coils are all badly insulated, and there is leakage to earth through the base-plate, the dynamo will not give current. It may be that one of the coils only is defective, in which case the dynamo will give current, but the current will be much weaker than normal.

(*d*) *Short-circuit in the Armature Coils.*—Short-circuit in the armature coils would introduce a shunt of greater or lesser resistance between certain points, and as a result an integral part of the exciting current would be absorbed between those points instead of it passing through the whole of the coil, and there would be a loss of power in the magnetic field. In series-wound dynamos the current would be weakened, and the defective coil would heat less than the one in good order. In shunt-wound or compound-wound dynamos both coils would heat equally.

To find the defective coil, a separate test should be made of the resistance of each of them after removing every outside connection. For this purpose a Wheatstone bridge and resistances, a sensitive galvanometer, and a battery of three or four cells should be employed. If this apparatus is not procurable, a battery and galvanometer connected

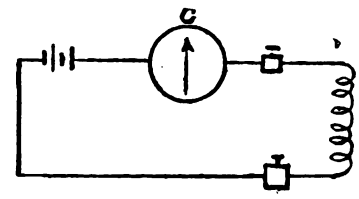

FIG. 2

with the coil in the manner shown in Fig. 2 may be substituted. The deflection given by the galvanometer with each coil should be noted. The coil in which the short-circuit exists will give a much larger deflection than the others.

(*e*) *Short-circuit on the Commutator.*—A short-circuit caused by copper dust connecting two or more sections of the commutator is sufficient to prevent the dynamo from giving current. A minute examination of the commutator, with, if necessary, a test with battery and galvanometer or bell, will always result in the detection of this fault.

(*f*) *Short-circuit at Some Point of the Wiring.*—Means of detecting short-circuit in the dynamo or the external current have already been described. To localise the fault, if it exists in the external circuit, the conducting wires which were removed from the terminals of the dynamo should be sharply replaced, and the cut-out nearest to the fault (if cut-outs are employed) will blow. Otherwise the conductor at the fault will be heated, and the insulating substance covering it will probably take fire. If the short-circuit is of serious extent it is probable that when the conductors are reconnected to the dynamo at a moment when the latter is running at normal speed, the belting will slip from the pulley. In such case the fault may be discovered with a battery and galvanometer in the following manner:

All the lamps or apparatus should be disconnected and the conductors left open. That done, the wires from the battery, P, Fig. 3, should be led—one to the point of departure of the main lead, *m*, and the other to the terminal, *g*, of a galvanometer, G. Another wire should be taken from the terminal, *g*, of the latter to the other main lead, *n*. If the circuit is in order the galvanometer

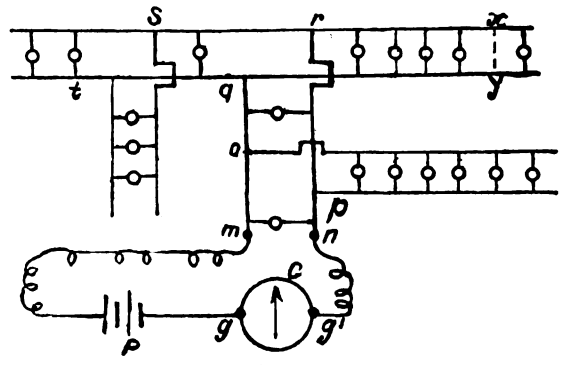

FIG. 3.

will not give any deflection—the two main leads being insulated from each other. If the circuit is faulty—supposing, for instance, that there is a short-circuit at *x y*—the branch circuits should be detached one by one—that is to say, *o p*, *q r*, *s t*—and once the fault is localised on branch *q r*, it is easy to find and repair it.

If the test shows that the external circuit is in good order, the fault must be looked for at or near the ends of the conductors nearest the dynamo, and will probably be found in the wires connecting the dynamo with the switch-board, or in the switchboard itself. A bad short-circuit,

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such, for instance, as that sometimes produced by defective lampholders, will prevent the dynamo from giving current. It is very necessary to thoroughly examine and test the connections of the lamps or other apparatus in the main or branch circuits, as well as the switchboard, before reconnecting the main leads to the dynamo; and whenever short-circuit is indicated in the external circuit, the dynamo should be disconnected until the fault is localised and repaired.

REDUCING THE CAPACITY OF LONG-DISTANCE TELEPHONE LINES BY MEANS OF SELF-INDUCTION.

BY DR. MAX REITHOFFER.

It has frequently been observed on long-distance telephone lines (Vienna-Prague, or Vienna-Trieste) that the transmission between the two terminal stations is very much improved by cutting into the main line one or several way stations possessing self-induction. Indeed, the transmission between Vienna-Prague is greatly improved by introducing into the main line the way stations Brunn, Iglau, Kolin, and, as a matter of fact, each sub-station is found to improve the clearness of transmission.

This phenomenon is attributable to the large capacity of the line in consequence of which the charging currents overpower the talking currents. On account of the great resistance of the line, there is, of course, a considerable fall of potential; in other words, the variable E.M.F. set up at the transmitting station arrives greatly weakened at the distant station, and this attenuation of the legitimate talking currents is accentuated by the existence of capacity on the line. To improve long-distance transmission, we must cast round for means to neutralise the charging currents, or to cut them down as much as possible.

FIG. 1.

It is well known that the current received by a condenser, placed between points A and B of a line supplied with alternating currents, shows a phasal difference of 90deg., while the current passing through a coil with self-induction in parallel with the condenser at points A and B, lags by an angle ϕ, whose tangent is tan $= \frac{2 n \pi l}{r}$ (n = number of periods; l = coefficient of self-induction, and r = wire resistance).

If it were possible to make ϕ = 90deg., the two currents would be in opposite phases, and by equalising their amplitudes, their combined current would neutralise one another. In reality, such a phase difference (180deg.) can only be approximated, and the resulting current may be made very small, but can never equal zero; thus the loss of potential of the line becomes insignificant and the legitimate current increases.

It is desirable to find some means for strengthening the talking currents of long-distance telephone lines. A telephone loop may be replaced by two lines having no capacity, but a number of small condensers in parallel branch between the two conductors. Again, we may replace a number of such condensers by a single one inserted exactly in the middle of the two conductors, and having a capacity eqnal to one of them.

M represents the sending, N the receiving station; T and T' are telephones, s and s' the secondaries of the transmitter induction coils; C the condenser of a capacity equal to that of the loop.

For the purpose of our consideration we assume that the E.M.F. of the secondary at M is known, and varies in accordance with the law of sines, the mean period being N = 500.

It would not be a difficult task to find the exact current passing through the telephones at the receiving station, but as we desire only approximate figures, it seems best to make a general computation, having in view some definite data, and to this end we will base our computation on the line Vienna-Prague (320 kilometres).

The exact data of this line are as follows:

Resistance of loop = 1,400 Ω.

Resistance of one second transmitter induction coil = 180 Ω.

Resistance of one telephone coil = 200 Ω.

Coefficient of self-induction of one of the secondary transmitter induction coils = 0·7 h.

Coefficient of self-induction of one telephone = 0·1 h.

Capacity of loop = 3 microfarads.

Designating by R the resistance of that part of the line on the right side of A B; the sum of the coefficients of self-induction by L; calling R_1 the ohmic resistance of the line on the left of A B; L_1 the sum of the coefficients of self-induction, and not taking into account the second transmitter induction coil at M, we have

$$R = 1{,}280\ \Omega. \qquad R_1 = 1{,}280\ \Omega.$$
$$L = 0{\cdot}9\ h. \qquad L_1 = 0{\cdot}2\ h.$$

We will now compute the current, i, which starting from N reaches the telephones, assuming that C is between A and B, and is itself shunted by an induction coil. In this case the effect of C is materially weakened, and we may commence our computation by considering the effect of C as being suppressed, or as there being no condenser.

In the first case, to find the relation between the E.M.F., e, in M and the current i, we consider $\delta = \Delta \sin w t$, the potential at the terminals of the condenser. If $w = 2 n \pi = 1{,}000 \pi$, we have

$$\tau_1 = \frac{\Delta}{\sqrt{R^2 + w^2 L^2}} \sin (w t - \phi) = J_1 \sin (w t - \phi).$$

The apparent resistance of the right part of the cone $\sqrt{R^2 + w^2 L^2}$ may be R^1 or $R^1 = 3{,}120$. Consequently,

$$\Delta = J_1 R^1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$
$$\delta = J_1 R^1 \sin w t \quad . \quad . \quad . \quad . \quad . \quad (2)$$

and the current, τ_2, passing through the condenser is

$$\tau_2 = C \frac{d \delta}{d t} = w C \Delta \cos w t \quad . \quad . \quad . \quad (3)$$

Inserting in this equation the value of Δ as given by (1), we have

$$\tau_2 = w C R^1 J_1 \cos w t = J_2 \cos w t \quad . \quad . \quad (4)$$

In other words, whether or not the charging current, ϵ_2, is stronger than the legitimate current, τ, depends solely on the quantity $w C R^1$. In our computation this product is equal to 29·4, or the condenser current is 29·4 times as large as the talking current.

To find the resulting current, i, we must venture τ_1 and τ_2. For an approximate first computation we may well neglect τ_1 and thus work

$$\tau = \tau_2 = (w C R^1). \quad J_1 \cos w t \quad . \quad . \quad (5)$$

An accurate computation decreases the value of τ (28·5 J_1, instead of 29·4 J^1), and the current lags 1 – 2 degrees compared with τ_2.

From δ_1 and τ the relation between E and J_1 are easily established.

$$e = \delta + \tau \sqrt{R_1^2 + w^2 L_1^2},$$

but $\sqrt{R_1^2 + w^2 L_1^2}$

is the apparent resistance of the left portion of the loop, R_1, its value being 1,430.

Now using equations (2) and (5) we have

$$e = J_1 R^1 \sin w t + J_1 R^1 w C R_1^1 \cos w t \quad . \quad (6)$$

Again taking $e = E \sin (w t + \phi)$ then

$$E = J_1 R^1 \sqrt{1 + (w C R_1^1)^2} \quad . \quad . \quad . \quad (7)$$

But as $(w C R_1^1)^2 = 180$ we may neglect (7) and write

$$E = J_1 R^1 w C R_1^1 \quad . \quad . \quad . \quad . \quad (8)$$

or,
$$J_1 = \frac{E}{w C R^1 R_1^1} \quad . \quad . \quad . \quad . \quad . \quad (9)$$

or, expressed numerically,

$$J_1 = \frac{E}{42{,}000} \quad . \quad . \quad (10), \text{ and } = \Delta \frac{E}{13{\cdot}5}.$$

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But if there is no condenser we find the current directly considering merely the entire apparent resistances—*i.e.*,

$$J_1 = \frac{E}{\sqrt{(R + R_1)^2 + w^2 (L + L_1)^2}} \quad . \quad (11)$$

expressed numerically,

$$J_1 = \frac{E}{3{,}480} \quad . \quad . \quad . \quad (12), \text{ and } \Delta = \frac{E}{1{\cdot}11};$$

or the intensity of the current without a condenser would be twelve times as great, a conclusion independently arrived at by Dr. Sakulka.

The percentage loss in potential from M to A B—*i.e.*, $\frac{E-\Delta}{E}$ ·100 as in the first case 92·6 per cent., in the second 9·9 per cent. However, as it is impossible to neutralise the charging currents entirely as we have assumed, the increase in the talking current will not be quite as good. Again—as see equation (9)—l appears in the denominator, the first current arrangement becomes more disadvantageous with an increase in capacity.

It should be borne in mind that a decrease of the condenser effect increases not only the amplitude of the transmitted waves, but affects also materially their distinctness; and this is most pronounced with compound waves or undulations, such as are produced in voice transmission.

This fact depends in both equations on the value of w; in other words, the amplitudes, J_1, of the respective currents must correspond to the number of vibrations, n. Transmitting compound vibrations, the amplitudes of the single component vibrations on arriving at the distant station have been changed or modified. Graphically represented, the curve of the current at the transmitting station arrives at the receiving terminal station in a distorted condition, such distortion increasing with the more or less pronounced effect which the number of vibrations has on the amplitude of the current.

Considering now equation (11), the influence of w may be insignificant, the value of R and R_1 being great; on the other hand, imagining the most disadvantageous condition, w remains a linear function of the denominator. Using a condenser—compare equation (9)—J_1, in its most favourable condition, will be inversely proportional to w, and in its most disadvantageous condition inversely proportional to w^3, because w is a factor of R^1 and $R_1{}^1$; in other words, the clearness and distinctness of voice transmission is greatly aided by suppressing the condenser effect of a telephone loop.

But in order to cut down the condenser effect by shunting the line with the secondary of an induction coil two conditions are required.

The current phase of the coil must lag 90deg. behind the phase of the E.M.F., and its amplitude must equal that of the condenser. Signifying by l and r, respectively, the coefficient of self-induction and resistance of the coil, we have $w\,l$ large as compared with r, because $\tan \phi = \frac{w\,l}{r}$, and

$$\frac{1}{\sqrt{r^2 + (w\,l)^2}} = w\,C.$$

It is sufficient to make $\tan \phi \geqq 10$, and $w\,l \geqq 10\,r$; we now have for our second equation

$$\frac{1}{w\,l} = w\,C, \text{ and for } l = \frac{1}{w^2\,C} \quad . \quad . \quad . \quad (13)$$

For our computation we require a self-induction of about 0·034 h, and a resistance less than 10 Ω. We also assume that the coil has no iron core. Hysteresis and Foucault currents decrease the phasal difference, and if iron cores are used they should be laminated.

In fact, a coil in which $w\,l$ is great compared with r may be considered a condenser of negative capacity, its value being $C_1 = -\frac{1}{w^2\,l}$. Placing such a coil in parallel current with a condenser, C, it may be said that such an arrangement represents another condenser, C_0, whose capacity is

$$C_0 = C_1 + C, \text{ or } C_0 = C - \frac{w^2\,l}{1} \quad . \quad . \quad . \quad (14)$$

In case l is equal to $\frac{1}{w_2 C}$, C_0 must approximate zero. Equation (14) shows how a coil with different values of self-induction may be advantageous or injurious.

Our entire computation so far has been based upon the assumption that the entire capacity of the line may be replaced by a condenser inserted in the middle of the line. It stands to reason, however, that we shall better approximate the real conditions of a commercial line if we insert a number of condensers of small capacity between the out and return conductors of a loop. For instance, we might at each 10 kilometres distance place coils whose constants had been computed for the capacity of 10 kilometres of conductor. Such an arrangement, according to Preece, would diminish the capacity of the loop, its characteristic product becoming smaller.

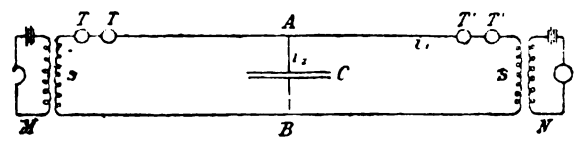

Fig. 2.

The same considerations which we have applied to a loop hold good for a grounded line.

It will be remembered that long ago De la Touanne, while constructing the aerial telephone line between Paris and Rheims, called attention to the improved transmission over a long-distance line brought about by inserting in parallel circuit coils having self-induction. The same phenomenon was noticed by Cailho, in 1890, on the cable between Calais and Dover. But all these arrangements differ from the one here described by inserting the self-induction as a shunt, at the terminal stations; on the contrary, we assume that the self-induction is placed in the centre of the line, or in several intermediate stations.

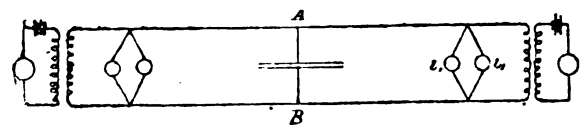

Fig. 3.

Both Cailho and De la Touanne committed the mistake of using coils with an excessively large self-induction; thus they concluded that the smaller the coefficient of self-induction of the coil or coils, the more advantageous would be the use on a long line; but equation (14) shows that by going below a certain value the opposite result takes place.

Cailho made experiments on the line Paris-Beauvais, placing the telephones in a shunt, either in series or in parallel, and he claimed that such an arrangement produced an improved transmission. This phenomenon does not depend, however, so much upon a weakening of the charging currents as upon a favourable arrangement of the circuit resistance. In fact, such an arrangement may advantageously be employed for lines having a large capacity and comparatively small resistance.

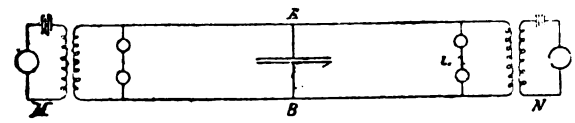

Fig. 4.

In his experiments with the 80 kilometres underground line Paris-Beauvais, Mr. Cailho employed the following values:

Resistance of the loop, 1,340 Ω.
Capacity of each condenser, 15·6 microfarads.
Coefficient of self-induction of one telephone, 0·15 h.
Resistance of one telephone, 200 Ω.
Resistance of the secondary of the transmitter induction coil, 150 Ω.

The coefficient of self-induction of the secondary of the transmitter induction coil is not stated; we assume its value to be 0·7 h.

Again, using our simplified equation—*i.e.*, replacing the

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capacity of the entire loop by a single conductor inserted in the centre of the line—we may represent this new arrangement by Figs. 3 and 4.

Omitting for the present in our computation the capacity of the entire line, we have the following values for J_1, the amplitude of the current in the telephones at the receiving station :

$$\left.\begin{aligned} \text{By Fig. 2, } J_1 &= \frac{E}{4{,}750} \\ \text{,, } 3, J_1 &= \frac{E}{4{,}500} \\ \text{,, } 4, J_1 &= \frac{E}{2{,}780} \end{aligned}\right\} \quad . \ . \ . \quad (15)$$

It is evident that cutting the high apparent resistance of the secondary of the transmitter induction coil out of the telephone circuit is advantageous in the circuits shown in Figs. 3 and 4 ; in fact, the secondary constitutes there a relatively high shunt to the telephones. On the other hand, the transmitting station is not so favourably affected by the existence of a local circuit, constituted by the telephones in a parallel branch with the main line. In other words, only a portion of the E.M.F. originated at the transmitting station affects the line. Nevertheless, the final result demonstrates the advantage of such disposition, and the latter becomes more advantageous by a consideration of the large capacity of the line—*i.e.*, 31·2 microfarads. A condenser of capacity C (besides its effect upon the phase of the current) represents a resistance of the value $\frac{1}{w C}$, but

$$C = 31{\cdot}2\ 10^{-6} f \text{ or } \frac{10^6}{2 n \pi\ 31{\cdot}2} = 10{\cdot}2\ \Omega,$$

or a relatively small resistance. Again, in all three circuit arrangements the charging currents are 80 times as great as the telephone currents, and we see that the advantages of arranging the circuit, as shown in Figs. 3 and 4—*i.e.*, cutting down the resistances in the telephone circuit proper—remain undisturbed, while the disadvantages—loss of charging currents—become less important.

Setting aside the somewhat involved mathematical deductions, we will at once state their results in which Δ expresses the potential at the condenser terminals, and J^1 the amplitude of the arriving telephone current :

$$\left.\begin{aligned} \text{By Fig. 2, } \Delta &= \frac{E}{151} \ ; \ J = \frac{E}{509{,}000} \\ \text{,, } 3, \Delta &= \frac{E}{100} \ ; \ J = \frac{E}{178{,}000} \\ \text{, } 4, \Delta &= \frac{E}{83{\cdot}2} \ ; \ J = \frac{E}{132{,}000} \end{aligned}\right\} \quad . \quad (16)$$

Equation (16) shows that although in (3) and (4) amplitude of the charging currents is larger, there is less loss of potential on the line up to the condenser. On account of the decreased resistance of the telephone circuit, the arriving telephone currents are greater than the increase of potential, Δ, would indicate. A comparison between the values of (15) and (16) proves conclusively how injuriously a telephone line is affected by its capacity ; also how much the talking currents are strengthened by reducing the condenser effect by means of suitable self-induction.—*Electrical Review* (New York).

INSTITUTION OF ELECTRICAL ENGINEERS, Jan. 11.

INAUGURAL ADDRESS OF MR. ALEXANDER SIEMENS, M.I.C.E. (PRESIDENT).

In taking this chair, and in thanking you sincerely for having elected me to be your President during this year, it is only natural that I should remind you of the fact that the late Sir Wm. Siemens was your first President. For this reason I may claim to be the first representative of the second generation of electrical engineers who have been called into separate existence by the founding of this Institution 22 years ago. During this period the Institution has grown from small beginnings to its present flourishing condition, thanks to the ability and energy of its founders and of my predecessors in this chair, who have spared neither time nor trouble to secure for electrical engineers the position to which the growing importance of the applications of electricity entitles them. In these endeavours they have been most ably assisted by the permanent staff of our Institution ; but the greatest aid has been the benevolent friendship of the parent institution and its officers.

The permission to use this hall for their meetings started the Society of Telegraph Engineers with a standing in the engineering world that it would have cost years of work to achieve elsewhere ; and the kindly counsel of the veteran secretary of the Institution of Civil Engineers has often guided the society in times of difficulty during the period of infancy, and we sincerely hope that he will long continue his useful work in this building. The contrast which exists in the applications of electricity at the time of the founding of this Institution and at the present time has been so clearly and ably put forward by Mr. Preece in his address last year, that it would be wasting your time if I entered into any details to illustrate the progress. On the other hand, it may not be out of place to analyse the various factors which have influenced the development of our profession from the time at which telegraphy was the only important practical application of electricity, until now, when it is called upon to supply energy for an immense variety of purposes.

During the past 22 years our profession, and with it the Society of Telegraph Engineers, have changed their character, until these and the scope of their activities have become much more comprehensive, and much more intimately connected with the everyday life of the general public. With reference to this, telegraphy may be compared to the railways, as they both are for the indiscriminate use of the general public, and it is only an exception if a railway or a telegraph line is constructed for private purposes only. For working both these lines a special staff is required, and general rules for their use have to be adhered to by everybody ; while in the modern applications of electricity the chief aim is to distribute the electrical energy so that each individual user can apply it in the manner and during the time that it best suits his convenience.

I need not recapitulate the reasons which for a long time made this distribution of electrical energy commercially impossible ; but when these difficulties had been overcome, and the electrical engineers were ready to supply the public, it was found that, excepting the Corporation of the City of London, there existed no authority in the United Kingdom that could permit the laying of underground mains, and that a special Act of Parliament was requisite. To the unsophisticated mind this appeared to be extremely simple, as all that was needed was to extend the powers of the various authorities to whose care the laying of water and gas pipes and of telegraph lines was entrusted, so that they could deal in a similar manner with electricity mains. Some of the electric light companies were of opinion, however, that the same object would be attained if they received powers from Parliament to make agreements with the local authorities, subject in every case to the approval of the Board of Trade, for establishing a system for distributing electrical energy in the various districts ; and in pursuance of this policy several private Bills were filed for the session of 1882.

The Government of the day did not consider it to be of public advantage that a limited number of electric light companies should have such roving powers, but brought in a general Bill with the intention of facilitating and expediting the general application of electricity.

With this object in view, powers were to be given under the Bill to the Board of Trade to grant licenses or provisional orders to electric light companies.

The license to establish a system of electrical distribution in any district was to be granted to an electrical company who had succeeded in gaining the consent of the local authority ; and its conditions were to be settled between the local authority and the company, subject to some general provisions to be drawn up by the Board of Trade, and subject to the sanction of the Board of Trade.

In districts where the local authority objected, the elec-

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tric light company should, nevertheless, be able to establish itself by means of a provisional order of the Board of Trade; but to obtain this the company had to prove that the majority of the inhabitants of the district desired to have facilities for obtaining electrical energy. It will be observed that in this draft the license was intended to be the usual way of obtaining power to lay underground mains, and the formalities for settling it were extremely simple; the provisional order, on the other hand, was to be resorted to in exceptional cases as a means of overcoming the objection of local authorities. This is confirmed by the fact that in the draft the duration of the license and of the provisional order were equal.

These benevolent intentions were, however, thoroughly upset during the passage of the Bill through Parliament, and the Electric Lighting Act (1882), which was the outcome of the discussions before a Select Committee, has given rise to angry denunciations on account of the obstacles which, in the opinion of many, it was raising to an early introduction of lighting by electricity on a large scale. Curiously enough, nobody during the passing of the Act, or afterwards, seemed to care much about the fate of the licensing system, which was completely stripped of its importance, and alluded to by the learned counsel on both sides as suitable only for experimental purposes. Following up this train of ideas, the duration of a license was curtailed to seven years.

Had the intention of the Government, however, been carried out as at first designed, we should now enjoy in the United Kingdom the same facilities of establishing electric supply systems that have aided the development of the electrical industries so much in other countries, instead of being obliged to apply to Parliament in each separate instance, at great trouble and expense. Disregarding entirely this vital alteration of the Bill, another provision was seized upon to explain the failure of so many electric enterprises to which the aid of the public had been invited about that time. You all know that this was the clause giving the local authority the right to buy out the electrical company after the lapse of 21 years, paying only the market value of the plant. This agitation was continued until, seven years later, the objectionable clause was modified, and in consequence of this alteration it was said that the confidence of the public in electrical enterprises had been restored. At the same time, the system of granting powers by way of a license was practically dropped altogether, and since then the Board of Trade has declared its intention not to grant provisional orders to electric light companies unless they have obtained the consent of the local authority, thereby abandoning entirely the original object of the provisional orders. The ultimate result of all this legislation has, therefore, been to create a number of difficulties in the establishment of distributing systems in the United Kingdom; in fact, the formalities of applying for a provisional order are very similar to those required for a private Bill, so that practically we are not in a very much better position than before the passing of the Electric Lighting Act, 1882.

In order rightly to understand the influence which this legislation exercised on the development of the electrical industry, it is necessary to examine into the character and the number of the applications made to the Board of Trade under these Acts, and to trace how many of them have led to the establishment of distributing systems. Taking first the case of the electric light companies, or, as the Act calls them encouragingly, "the undertakers," we find that in 1883, 55 provisional orders were granted, all of which have been revoked; in 1884, three provisional orders and one license were granted, all of which have been revoked; in 1885, one license was granted for the lighting of St. Austell, and this has been put into operation; in 1886, one provisional order was granted to the Chelsea Electricity Supply Company: this also has been carried out; four licenses granted during the two following years, 1887 and 1888, have since been revoked; so that, up to the time of the passing of the amending Act (1889), one license and one provisional order are the sole survivors. These facts clearly indicate that under the Electric Lighting Act, 1882, the undertakers have not succeeded in their object to make electrical energy obtainable as a household commodity. It is, of course, quite another question whether there were not very strong causes of another kind which prevented the powers obtained under the Act from being exercised.

Since the Electric Lighting Act, 1889, was passed, a new impetus was given to these enterprises, and, without examining the result of each year's applications separately, the grand total of the undertakers' efforts is that since 1882 138 provisional order have been applied for, and 15 licenses; of these, 81 provisional orders and nine licenses have been revoked, so that 57 provisional orders and six licenses are still in force. To this number two provisional orders have to be added, which have been transferred from local authorities to undertakers. An electric supply has been established, or the work is actually taken in hand, in 54 cases, and about 53,000 h.p. will be available. On the other hand, of local authorities, a few had obtained powers under special Acts. The City of London, as mentioned above, had been able to make some experiments of street-lighting without any special permission; but a number of them availed themselves of the opportunity given by the Electric Lighting Acts, and obtained 121 provisional orders and six licenses up to the end of last year. Of this number eight provisional orders and four licenses have been revoked, or merged in provisional orders, so that 113 provisional orders and two licenses granted to local authorities are still in force; but two of the provisional orders have been transferred to undertakers, as mentioned above. Under these powers, 51 electrical systems of distribution, with 35,000 h.p., have been established or are in course of construction, while in almost all the other instances the intention soon to carry out the work is apparent. With your permission, a table, giving the details of all these applications and of their fate, will be added to the address, if you consider it worthy to be printed in the *Transactions* of our Institution.

From the figures which I have given, it is, however, plainly apparent that the local authorities will very shortly have a good many more stations at work than the electric lighting companies; and, in my opinion, this is as it should be. The financial success which has invariably attended the municipal electric enterprises has relieved the rates at the expense of the wealthier classes in a perfectly legitimate manner, and the more electricity becomes one of the common necessaries of life, the better it is that its supply should be in the hands of the community, and not in those of monopolists.

A strange fact in connection with this subject is that the great majority of the local authorities should have waited until the passing of the Electric Lighting Act, 1889, before applying for powers to supply electricity, for it must not be forgotten that their position was in no way affected by the alteration of the Electric Lighting Act, 1882. The explanation must perhaps be looked for in the exaggerated expectations that were raised by the statements of company promoters in the year 1882, when the most reckless assertions were made as to the results to be obtained by establishing electric systems of distribution. The natural consequence was that the enquiries set on foot by various local authorities in no way confirmed the sanguine estimates that had been dangled before the public to obtain its support; and the total failure of the electric light companies to carry out a single one of the orders and licenses obtained by them in the years 1883 and 1884, made the local authorities hesitate before they embarked the ratepayers' money in such precarious undertakings.

Fortunately, for the progress of our industry, there were some corporations who could be convinced by the result of their enquiries that the use of electric light would be very advantageous for a variety of purposes, and that the knowledge and ability of the electrical engineers had progressed sufficiently to make a profitable distribution of electricity from a generating centre possible. We have seen that their example has been largely followed, and there is every prospect of a continuous and ever-increasing development of this branch of electrical engineering. To be sure, in foreign countries, especially in the United States, the use of electricity is much more common than here; but this is the natural outcome of the greater facilities for establishing centres of supply under the laws of the various countries, where the local authorities in the majority of cases have

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the power to make agreements with electrical companies for supplying the district with electrical energy for various purposes.

Another important factor in retarding the spread of the applications of electricity in this country is the otherwise very laudable desire of the electrical engineers to show in every new undertaking a distinct advance on its predecessors. In this way the details of construction are undergoing a constant change—in strong contrast to the United States, where the leading manufacturers have their standard sizes of plant and accessories; these are manufactured wholesale by specially-designed machinery, and can therefore be supplied much more cheaply than apparatus specially constructed for each case. At the same time the whole transaction is greatly simplified by the absence of long negotiations about the construction of the apparatus, the town which is to be lighted simply specifying how many incandescent lights and arc lights are to be supplied.

This system of working has certainly been instrumental in accelerating the introduction of electricity for a variety of uses throughout the States; but it can hardly be pretended that such a cast-iron application of the same apparatus under a variety of circumstances can lead to the most economic results, nor has it been possible to keep up the quality of the work to the English standard. Those of you who have visited the World's Fair at Chicago last year, and have examined a little into the details of workmanship and design, will doubtless agree that Sir Richard Webster was fully justified, in his address to the Society of Arts, in contrasting the American and the English exhibits in this respect, very much in favour of the latter. However much other causes may have contributed to delay the development of electrical engineering, it is clear that the principal one must be looked for in the exaggerated expectations that were raised, either by ignorance or design, when the general public first seriously thought of regarding electricity as a commodity for everyday use. At that time the promoters of electric companies preached to the public that electricity was in its infancy, that the laws of this new science were totally unknown, and that wonders could be confidently expected from it. There was a short time of excitement to the public and of profit to the promoters; then the confidence of the public in electricity was almost destroyed, and could only be regained by years of patient work.

That the electrical industry was not altogether killed by all these adverse factors is undoubtedly due to the firm scientific basis on which it rests, and to the advantages which the applications of electricity possess as compared with other means for accomplishing the same ends. In a discourse before the Royal Institution I had an opportunity of reminding the audience that during the last 60 years the most eminent scientific men have studied the phenomena produced by electricity, and that, in consequence, the laws which govern electric currents were perfectly well known when the supply of electricity on a large scale became commercially possible. Since that time the study of electrical phenomena has been carried on with even greater zeal than before, and electrical engineering is now in no danger of lagging behind for want of theories, but is largely aided in its progress by the painstaking investigations carried on in many laboratories, both in England and abroad. While electrical engineering is thus closely allied to physical science, it has quite as intimate a relation to mechanical engineering; in fact, its real progress dates from the time when the close connection of electrical and mechanical engineering was thoroughly recognised; and since then these two branches of engineering have reacted on one another to their mutual advantage.

The contrast between present practice and that of the pioneers of our profession is at once recognised in reading the first papers and reports on dynamo-electric machines, where particular stress is laid on the small size and on the low weight of a dynamo to produce a given result; but the necessity of having the moving parts durable, and of not always working the machine up to its maximum power, was completely ignored in the desire to produce a large effect with the minimum expenditure of materials. A glance at a modern dynamo, especially when it is built on the same lines as a machine of 20 years ago, will at once reveal the progress of mechanical design that has taken place in the interval. The circumstance that at first only weak currents of electricity were utilised for practical purposes, and that during this period the electrical appliances were constructed like scientific instruments, had undoubtedly brought about this neglect of mechanical considerations, and a healthy reaction could only take place after the mechanical engineer had taken the management of the applications of electrical energy from the hands of the physicist.

On the other hand, the requirements for driving dynamos to the best possible advantage have served as no mean incentive for mechanical engineers to introduce a number of important improvements into the design of steam-engines; in fact, the class of high-speed economical engines may be said to have been called into existence by them, and this has led to the use of direct-driven dynamos, in which this country undoubtedly has taken the lead. In another direction the governing of the speed of the steam-engines has been vastly improved, although at first the mechanical engineers regarded the complaints of the electrical engineers simply as an excuse to shift the blame for the bad performance of their dynamos on to the steam-engine. They very soon learned, however, the importance of running at an unvarying speed, and the result is that even comparatively cheap steam-engines can be obtained nowadays that govern infinitely better than a high-class engine of 20 years ago.

(To be continued.)

At last night's meeting of the Institution, after the formal business of reading and signing the minutes, the retiring **President** presented the premiums to Mr. Sayers and Mr. Cooper, and then introduced the new president, Mr. A. Siemens. Then **Sir D. Salomons**, rising, proposed a hearty vote of thanks to the retiring president, which was seconded by **Mr. Crompton**, carried, and duly responded to.

The following candidates were balloted for and elected:

Foreign Members.—Prof. Paulo Benjamin Cabral, Inspector-General of Telegraphs, Lisbon; Prof. Carhart, Michigan University, Ann Arbour, Michigan, U.S.A.; Samuel Insull, the Edison Electric Light Company, Chicago, U.S.A.; F. Jacques, the Western Union Telegraph Company, San Francisco; Dr. Claudiano Luiz Pinna, Pernambuco, Brazil; Arnold von Siemens, 94, Markgrafen-strasse, Berlin; Wilhelm von Siemens, 94, Markgrafen-strasse, Berlin; Carl Albert Unbehaun, Telegraph Department, Adelaide, South Australia.

Member.—Lester Bruce Betts, Maitland Lodge, Bournemouth.

Associates.—Robert J. Anderson, Eastern Telegraph Co., Suez, Egypt; Albert Barron, "Woodmancote," Lyndhurst-gardens, Hampstead, N.W.; Francis James Blake, 43, Clifton-hill, St. John's Wood, N.W.; William Boyd, 61, Trigon-road, Clapham-road, S.W.; Christopher J. Cummins, 12, Lower Abbey-street, Dublin; J. Birnie Evans, 29, Montague-road, Richmond, Surrey; Robert Charles Frewer, 9, Guion-road, Parson's Green, S.W.; J. K. Gibson, Eastern Extension Telegraph Co., Port Darwin, South Australia; Ernest Alfred Giles, Eastern and South African Telegraph Co., Zanzibar; Alfred T. Hailey, 26, Sloane-street, S.W.; Alfred John Harrison, Hermitage Works, Richmond; Clifford Hawkes, 22, Old-steyne, Brighton; Joseph Alexander Jeckell, Borough Electrical Engineer, South Shields; Walter C. Lang, Eastern Telegraph Co., Suez, Egypt; H. A. McCausland, 122, Sinclair-road, Kensington, W.; Herbert Henry Oswald, 15, Guildford-street, Russell-square, W.C; David Paisley, Edison and Swan United Electric Light Co., Limited, Ponder's End, N.; Arthur Portelli, Malta; William Pearson Richmond, Green Bank, Colne; Thomas Rooke, care of A. H. Preece, Esq., 39, Victoria-street, S.W.; Sydney G. C. Russell, 19, Lombard-street, E.C.; Arthur Leighton Stevens, 33, Pyrland-road, Highbury; Ronald H. Streatfield, 59, Charlotte-street, Portland-place, W.; Howard George Tozer, 11, Bridge-street, Northampton; Alfred T. Warren, 6, Aytoun-road, Brixton, S.W.

Students.—Arthur Anstruther-Thomson, Charleton, Colinsburgh, Fife, N.B.; Noel Broomhall, 2, Pyrland-road, Mildmay, N.; Sidney Phillips Doudney, Faraday House, Charing Cross-road, W.C.; George F. Heron, 14, De Vere-gardens, Kensington, W.; David Martin, 1, Provan-place, Govan, near Glasgow; Hugh Bernard Maxwell, Faraday House, Charing Cross-road, W.C.; Chas. Stanley May, Gower's Farm, Braintree, Essex; Frank John Rynd, Faraday House, Charing Cross-road, W.C.; N. B. Rosher, 33, Edith-road, West Kensington, W.; George Swetenham, 5, Inglis-road, Ealing, W.; Charles Percy Taylor, Westfield House, Bishop Stortford; Ralph Waldo Webster, Granville House, 90, Angel-road, Brixton, S.W.; George Edward Wright, Barclay-road, Croydon; R. J. C. Wood, 24, Sinclair-road, West Kensington, W.

At the conclusion of the Presidential Address, **General Webber** moved, and **Prof. Robinson** seconded, a vote of thanks to the President for his address, which was carried with acclamation.

At the next general meeting Mr. Preece will read a paper on his late visit to Chicago.

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THE
ELECTRICAL ENGINEER.

Published every Friday.

Price Threepence; Post Free, Threepence Halfpenny.

Editorial and Publishing Offices:

39-140, SALISBURY COURT, FLEET STREET,

LONDON, E.C.

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TO CORRESPONDENTS.

All Rights Reserved. Secretaries and Managers of Companies are invited to furnish notice of Meetings, Issue of New Shares, Installations, Contracts, and any information connected with Electrical Engineering which may be interesting to our readers. Inventors are informed that any account of their inventions submitted to us will receive our best consideration.

All communications intended for the Editor should be addressed C. H. W. BIGGS, *139-140, Salisbury Court, Fleet Street, London, E.C. Anonymous communications will not be noticed.*

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THE TENDENCY OF BUSINESS.

In our remarks last week we referred to the views expressed by Mr. Mordey as to the tendency of business, especially installation work, to be placed in the hands of one responsible authority, rather than for a number of contractors to be engaged, each, so to speak, responsible, yet no one responsible for the work as a whole. The desirability of personal responsibility for the work as a whole has long been one of our contentions, and we are glad to see it receiving almost universal acceptance. It is well known, also, that we are strong advocates of the employment of a consulting engineer, although Mr. Mordey may not agree with us on that point. At any rate, some of the principals of large companies rather prefer to design their own work and carry it out than to work to the design of an independent authority. But for the present we shall restrict our remarks to the question of personal responsibility. Mr. W. B. Esson, commenting on Mr. Mordey's remarks in a letter to us, says: "With reference to some remarks anent the gradual drift of particular kinds of business to particular manufacturers, and the sub-division of the trade into central station, isolated plant, small accessories, and wiring firms respectively, this was inevitable, and the fact denotes the approach of the final stage of the evolution of the industry. But one of the factors which has been not a little influential in quickening the development lies in the circumstance that the larger businesses have always had at call, through the influence of their Boards, a large amount of capital, and have thus been able to promote the forming of supply companies, and to take payment of the contracts they have carried out part in shares instead of cash. It is probable that the large manufacturing concerns will become in future simply electric supply trusts, with a factory tacked on, and an examination of several balance-sheets shows that this is more or less the case already. In the extent to which this obtains, I believe the electrical industry is quite unique."

This aspect of the matter is correct so far as it goes. The command of capital, and the ability to float sub-companies, has been an enormous advantage to some of our largest concerns, but in the evolution of the industry a turn is being taken that will remedy the evil brought about by subsidiary companies, and gradually the shares now held of such companies will be wiped out of balance-sheets. Before showing that this is so, we must insist that the welfare of the industry has been largely brought about because of the opportunities mentioned. Had not the large companies which could command capital *made* business rather than let it come to them, the progress would not have been half so rapid; and men would have waited—they are waiting now in many instances—because the "electric light was," or, as they argue, "is in its infancy." This fallacy has been knocked upon the head, thanks to the commercial energy and foresight of the principals of the big companies and the ability of their colleagues the engineers. A few years since many of the men who are now the strongest

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advocates for the action of local authorities were opposed to such action. When the local authority takes up the work the command of capital to form local companies is not wanted, nor is there any share capital of the subsidiary company found in the parent company's balance-sheet. It is in this direction that a change has come, and in the future will be more accentuated. There was a limit even with the strongest syndicate in forming sub-companies, but by this means they obtained a commanding position in the industry, and can now use that position to good account. What is an objection the smaller firm or the beginner has continually to face? Is it, as usually stated, the not having carried out similar work? There is always a lack of haste to give large work to inexperienced firms; hence those who have *made* their experience must, in the natural order of things, obtain first consideration from customers. The work done and the shares which figure upon the balance-sheet show so much capital sunk in obtaining a "goodwill," and "goodwill" under certain conditions is an extremely valuable asset. It may be made too much of, but that is another question.

BUSINESS DURING 1893.

(Continued from page 26.)

The BRUSH ELECTRICAL ENGINEERING COMPANY, LIMITED, have during the past year had their works employed upon all classes of electric lighting contracts, particularly those for plant for central electric lighting stations. The large and important contract for lighting the city of London has made great strides towards completion during the past year, there being now delivered at Bankside station (in addition to the plant originally put down there) six sets of Raworth-Mordey combined alternating plant, with an aggregate output of 2,500 kilowatts, and the equipment of the various transformer stations is now fast approaching completion. The original contract for lighting the town of Huddersfield has now been completed, and orders for considerable extensions have already been received. Additional plant has been supplied for the central stations at Sheffield, Bournemouth, Hastings, and Woking. Among the other central-station contracts secured during the past year may be mentioned those of Leicester, Lancaster, Dover, Canterbury, Fleetwood, Coatbridge, and those for the supply of alternators and arc lighting plant to the Great Northern Railway Company, Holloway, and to Hastings and Blackpool for lighting the promenades on the sea-front; alternators, exciters, and transformers to the Bolton Corporation; the complete equipment of the transformer sub-stations for Bristol; and the supply of alternate-current plant for the station at Rugby School. With some of these, and with the contracts previously secured for Corporation stations at Worcester and Hanley, considerable progress has been made; while the supply of plant for stations at Prescot, Windermere, and Killarney, and at several other places mentioned above, has been completed. The Brush Company's contracts for exhibition lighting have included this year the supply of the whole of the electrical plant at the Horticultural Exhibition, Earl's Court; and amongst the most important orders for isolated sub-stations in hand may be mentioned the lighting of Arundel Castle, the seat of his Grace the Duke of Norfolk; the residence of Sir Arthur Hayter, Southhill Park, Bracknell; Battenhall Mount, Worcester, belonging to the Hon. Percy Allsopp; High Trees Mansion, Redhill, belonging to M. Marcus, Esq.; and the supply of arc plant on a large scale for the important installation at the Midland Railway Company's station at Leicester. The installation work on shipboard completed by the Brush Company has comprised electrical plant for two vessels belonging to the Pacific Steam Navigation Company; two cruisers for the Argentine Government; extensions to the plant of the steam-yacht "St. George," etc. With regard to the internal organisation of the company, the special facilities possessed by the company in their woodworking and foundry departments at Loughborough have enabled them to contract for the exclusive manufacture of the lifts and hydraulic machinery to the orders of the Otis Elevator Company, an off-shoot of the American Otis Elevator Company, and it is anticipated that this will be an important branch of the Brush Company's manufactures in the future. Having perfected a system of alternate-current distribution, the company have been giving attention to the further development of their continuous-current plant. With this in view they have acquired the sole rights for manufacture in the United Kingdom of the Brush-Desroziers dynamo, a machine which has become a deserved favourite in the central stations on the Continent. They have also begun to manufacture several classes of two-pole dynamos of high efficiency and moderate price, which are finding many buyers. To all these types, as well as to their well-known Mordey-Victoria alternator, the company attach direct engines of their own special make. This does not, of course, preclude the supply of belt or rope drives where these are desirable, but is undertaken in order to meet the growing demand in central stations for direct driving. Important improvements have been made in the company's transformers, alternate-current arc lamps and lamp-posts, accompanied by substantial reductions in price, and, at the same time, particular prominence is being given to the supply of plain fittings, switches, and lampholders, which will shortly be on the market at most favourable figures. The expiration of the Edison patent in November removed an obstacle which had for years barred the field of incandescent lamp manufacture from general exploitation in this country. The Brush Company made extensive preparations to resume their former position in this branch of the electrical industry, relying on their name as a guarantee for first rate material and high-class workmanship, and feeling confident that the reappearance of their lamp would be welcomed on the market, where the Edison lamp had so long been in sole possession. They have been gratified by the ready and widespread sale with which the Brush incandescent lamps have met, and are looking forward to a steady and still larger demand than even the initial rush has brought upon Mr. Alwyn, of 53, Queen Victoria-street, E.C., in whose hands the whole of the sales in Britain has been placed. In its other departments also the company continue to be occupied fully with large and remunerative orders to an extent that taxes their resources to the utmost, notwithstanding the enlargement of their works and the increase of their staff.

DORMAN AND SMITH.—Although this firm have only occupied their new works in Salford for less than two years, they have already found it necessary to make extensions in several departments. Their manufactures, passing as they invariably do through the hands of large and small contracting firms

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before coming into the hands of the actual consumer, can hardly be analysed in a public announcement. Suffice it to say that their works have been kept fully employed throughout the year, and often on overtime. The leading firms have, as heretofore, demanded an enormous number of accessories, and a noticeable feature of the year is the fact that the thousand and one smaller contractors having now been in business for a sufficient length of time to learn the dangers attending the use of shoddy apparatus, are now compelled to use more substantial material. Their export trade, particularly with our colonies, has increased wonderfully in the last two years. Plenty of work also looms in the distance to keep all their machinery fully going during the new year.

LITHANODE AND GENERAL ELECTRIC COMPANY, LIMITED.—The year 1893 has been an exceedingly busy and progressive one for the Lithanode and General Electric Company, and they report a series of very successful operations. A very large number of portable hand-lamps and other small batteries have been disposed of, and, judging from the repeat orders which have been received for them in almost all cases, they have given entire satisfaction. During the past year many improvements have been made in the manufacture of lithanode, and it is thought that little can be done in the way of further improvements. Good lithanode of very high capacity and great mechanical strength can be made in 24 hours, whereas by the processes employed two or three years ago, the then inferior active material required from two to three weeks to produce. The improvements made have all tended to reduce the cost of production, and the material as now made enables the company to compete commercially in point of price with any other manufacturers. The Lithanode Company report that the names of most of the electrical firms of good standing in this country have been placed upon their books, and many substantial orders from the Continent, America, Australia, and South Africa have been successfully carried through. During the year there has been quite a large demand for lithanode batteries from medical men, and portable lithanode hand-lamps and other batteries for lighting purposes, and also batteries for medical cautery, have been in great demand. Many of the London and also provincial doctors are now using batteries supplied by the Lithanode Company. At the Admiralty, War Office, Science and Art Department, and other Government establishments, lithanode portable batteries are in great favour. The company have given much attention to batteries for vehicle lighting, and as an example of the successful illumination of vehicles may be cited the new Great Northern Railway omnibuses, which are said to be the most perfectly lighted vehicles to be seen in London. The whole of the lamps in these omnibuses are worked by lithanode batteries. There seems to be some misapprehension abroad with reference to the capabilities of lithanode accumulators, and it is generally supposed that this active material is only useful for cells of small dimensions and low capacity. This is an entire fallacy, for within the last 12 months many hundreds of tons of large lithanode cells have been sold; among these being a 220-cell battery for central-station work. Each cell in this particular battery has a useful current capacity of 650 ampere-hours, and is capable of being discharged up to as high a rate as 300 amperes. A large business has been done in the replacement of other makers' positive plates by the company's improved lithanode plates. The result of this combination has in all cases proved entirely satisfactory, and many hundreds of cells of various capacities have been treated in this way. The Lithanode Company's works are now fully equipped for supplying at short notice cells of the following capacities:

Capacity of cells.	Use of cells.
0·5 ampere-hours	Testing, medical, and theatrical purposes.
1·0 ,, ,,	
3·0 ,, ,,	Hand lamps.
5·0 ,, ,,	
6·0 ,, ,,	
8·0 ,, ,,	Portable accumulators for domestic lighting, broughams, tramcars, omnibuses, etc.
12·0 ,, ,,	
24·0 ,, ,,	
30·0 ,, ,,	
50·0 ,, ,,	Electric light installations, electric launches, tramcars, etc.
75·0 ,, ,,	
100·0 ,, ,,	
200·0 ,, ,,	
300·0 ,, ,,	
400·0 ,, ,,	
500·0 ,, ,,	
600·0 ,, ,,	
650·0 ,, ,,	Central-station work.

The company have not confined their operations to the manufacture of accumulators only, but, in addition to an extensive business in these goods, have carried out during the past year several important electric light installations. The Gresley Brewery, at Gresley, near Burton-on-Trent, has been entirely lighted by this company. This installation, which included dynamos, batteries, switch and distributing boards, instruments, etc., and between 200 and 300 lamps, possesses several novel features, and is an example of the economical utilisation of spare motive power by the aid of electrical storage. A 110-volt lithanode battery, with switchboard and all the necessary accessories, has recently been added to the electric light installation at the Tadcaster Brewery. The company are now engaged in putting down a large and complete electric lighting plant in the Cheltenham Brewery, the adjoining Fleece Hotel, and a moderate-sized private house. For this somewhat unique installation, which partakes somewhat of the character of a small supply station, perhaps the largest set of storage batteries ever put in a private installation is being employed. The batteries are for a 100-volt circuit, and will be capable of actuating between 500 and 600 lamps for a period of fully 10 hours when once charged. The installation will be in duplicate, there being two sets of accumulators and two dynamos, the switchboard being arranged so that either dynamo may run the lamps direct, or may charge one or both sets of accumulators. By this means the generating electrical plant may be arranged to suit the load of the engine, and as the installation can be run from either set of accumulators either separately or conjointly, it is thought that there will not be the slightest possibility of a complete breakdown. In addition to the work already enumerated, the company have carried out extensive alterations to the main switchboard of the General Post Office, London, and have also carried out some work in other important Government establishments. Electrical lighting for stage purposes has occupied a somewhat important position in the company's operations, and many electrical novelties have been carried out at the Alhambra Theatre, the Comedy Theatre, at the Crystal Palace, and at the New Olympic. The portable batteries now in use at Drury-lane Theatre have been supplied by this company, and perhaps the most extensive temporary installation of the electric light on the stage is now being carried through by this company for Mr. Oscar Barrett at the Lyceum Theatre. For scientific and testing purposes, lithanode batteries have been very successful, and many large testing batteries have been installed in several of the most important

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laboratories in this country. Among these may be cited a 100-cell 12 ampere-hour battery for Lord Kelvin's laboratory in Glasgow, and similar testing batteries have been supplied to the University College Laboratory, London; Board of Trade Electrical Department, London; the Brush Electrical Engineering Company, Loughborough; and the Brighton Corporation electricity works.

C. A. PARSONS AND CO. have during the past year supplied turbine engines to the Newcastle and District Electric Lighting Company, the Cambridge Electric Supply Company, and the Scarborough Electric Supply Company, showing an aggregate of 1,400 h.p., as well as numerous smaller plants of the steam-turbine class, and ordinary plants for ship, mill, and private house lighting, a total of about 2,000 h.p. They have in hand steam-turbine motors of an aggregate of over 3,000 h.p., including a 250-h.p. steam-turbine alternator for the Portsmouth Corporation. They have in hand as well contracts for search-light reflectors and other electrical specialities.

PATERSON AND COOPER.—This firm report that the past year has been one of unparalleled depression in the electrical engineering trade, but that they have, however, been fairly well employed. The following vessels have been fitted with complete installations: ss. "Matin," for Messrs. Mudie and Sons, Dundee; "Princess Beatrice," for Messrs. Langlands and Co., Liverpool; "Laurentian," for the Allan line; "Empress," for R. Carson, Esq., Hull; "Zaire," for F. T. Laws, Esq., Liverpool; "Noir-el-Bahr," for Messrs. Gourlay Bros., Dundee. Direct-driving sets for the ss. "Premier," of the Canadian Pacific Company, and for other vessels have been supplied. Complete search-light apparatus, with direct-driving set, has been supplied for a revenue steamer. The principal installations carried out have been the private residence of H. W. Buddicom, Esq., Penbedw, North Wales, comprising a direct-driving set, 108 L-31 accumulators, fitting of mansion with lights and bells, and several motors for sawing, pumping, churning, etc.; the private residence of M. G. Thorburn, Esq., Glenormiston, Peebles, comprising turbine and dynamo, cells, and fitting lights in mansion; Jury's Hotel, Dublin, 300 16-c.p. lights, with direct-driving set running at 175 revolutions per minute; the private residence of W. Prettey, Esq., Ipswich; Messrs. Flower's corn-mill at Ramsey; the Ocean Ironworks, Manchester; the Town Hall and Royal Hotel, Derby; the Great Northern Hotel, King's Cross; the Queen's Hall, Portland-place, etc. In small work, Admiralty contracts of considerable size have been executed. During the past year Messrs. Paterson and Cooper introduced their new patent five-ampere lamp, which has met with a very favourable reception; they have also brought out improved electrical measuring instruments, which have met with approbation, and have taken up the agency for Messrs. Richard Frère's electrical measuring and recording instruments. Of works at present in hand the most important are: Messrs. Buchanan and Sons' Works, Liverpool, 22 arc lights and dynamo; the private residence of R. K. Micklethwaite, Esq., Ardsley House, Barnsley; and the Municipal Buildings, Ealing.

SWINBURNE AND CO., LIMITED, report themselves as having been very busy throughout the year just completed, during the latter half of which they have been working overtime almost continuously. Amongst the most important contracts completed by them during this time is that for a set of motor-alternators for the Woolwich Electric Supply Company, to be worked in conjunction with the Pritchett secondary battery. Turning to other things, their small and large power alternators have met with great success, and the demand for these and for their ordinary direct-current machines shows signs of rapid increase. The same remarks apply to their new closed-circuit transformer, which has proved a great success whenever it has been tried, and is bound to have a large sale in the future on account of its many good qualities combined with very moderate price. In their instrument department they have devoted themselves chiefly to the perfection of the Swinburne electrostatic voltmeter, which is now gradually taking its place as the recognised alternating-current voltmeter on central-station switchboards. Their installation department has also made considerable progress during the year. They report having a large number of orders on hand in all departments, the outlook for the coming year being very promising.

WATERHOUSE ELECTRICAL MANUFACTURING COMPANY.—This firm state that, taking into account the delay which must necessarily be incurred in starting a new business, there is every prospect of the Waterhouse arc lamp being most successful. They are turning out lamps at the rate of 20 a week, and have many orders on hand. It is stated that soon the Waterhouse meter will be placed on the market, and it is thought by the company that it will be the meter of the future.

WILLANS AND ROBINSON state that the horse-power of the engines ordered from them during the year 1893 amounted to 18,950. This is a large increase on past years, and as it may be interesting by way of illustrating the growth of the business, and the increasing recognition of the merits of the Willans central-valve high-speed engine, to note the progress that has been made, we may say that the total orders booked in 1892 amounted to 14,300 h.p., and those in 1891 to 11,100 h.p. The engines ordered in 1893 vary in size from 40 h.p. to 570 h.p., and the majority of them are for direct coupling to dynamos. It is evident, however, that the Willans engine is coming into favour as a motor for supplying power as well as for lighting purposes, for recently orders have been given for several mill engines — among others, for one of 570 h.p. for a flax mill in Belfast, and another of 540 h.p. for a flour mill in Germany. Among the new electric light stations for which orders have been received during the past year may be mentioned the towns of Nottingham (650 h.p.), Aberdeen (320 h.p.), Lancaster (395 h.p.), Hampstead (860 h.p.), Warrington (270 h.p.), and Dewsbury (400 h.p.), and the following companies: Southampton Docks (light and power, 240 h.p.), Lancashire and Yorkshire Railway (300 h.p.), Royal Albert Dock (600 h.p.), Birmingham Grand Hotel (180 h.p.), and Holborn Restaurant (400 h.p.). The repeat orders during the past year from various companies who use these engines amount to 7,876—the principal ones being the Liverpool Electric Supply Company, (1,920 h.p.), the Westminster Electric Supply Corporation (1,160 h.p.), Brighton Corporation (720 h.p.), General Post Office (394 h.p), Birmingham Electric Supply Company (200 h.p.), St. James and Pall Mall Electric Light Company (550 h.p.), Bradford Corporation (400 h.p.), St. Pancras Vestry (400 h.p.), Bristol lighting (720 h.p.), Chelsea Electric Light Company (205 h.p.), Glasgow Corporation (720 h.p.). Many stations have, of course, been erected and started

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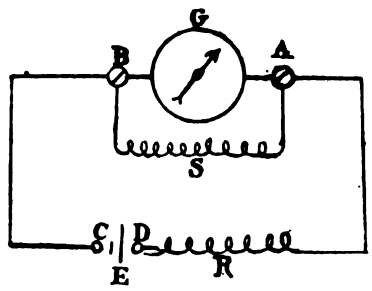
during the past year, the engines for which were ordered previously, such as Bristol (1,440 h.p.), Glasgow (1,210 h.p.), London and North-Western Railway (384 h.p.), City Lighting Company, Bankside station (1,440 h.p.), Dundee lighting (660 h.p.), Norwich lighting (300 h.p.). These figures are independent of the repeat orders mentioned above. At the Chicago Exhibition the company had two engines, one of 360 h.p. and the other of 165 h.p. These were driving shafting in the British section of the Machinery Hall, and we understand that for two months or more, owing to an accident to another engine in the section, they drove the whole of the shafting in it. Several other Willans engines were shown, one a 300-h.p. set coupled to a Siemens dynamo which was used for driving search-lights, and several smaller ones made by the M. C. Bullock Manufacturing Company, of Chicago, the American licensees. The total horse-power of the Willans central-valve engines now in use or on order amounts to 76,440.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

SHUNTS.

SIR, — Your correspondent "H. L." has in his last communication raised so many points on the above subject, that it is rather hard to answer him effectually without adding confusion to the maze of difficulties out of which he wishes to be led. His chief stumbling-block seems to be the "text-book" statement, that a shunt applied to a circuit diverts portion of the current flowing through that circuit. Perhaps the best method of helping him is to first examine clearly the effect of applying a shunt to, say, a galvanometer.



Take the case represented in this diagram. When the shunt is applied, the resistance between A and B is reduced to $\frac{G\,S}{G+S}$, and as this reduction affects the total resistance of the circuit, the E.M.F. acting between A and B may be also affected. I have said "may be," because there are cases in which it "may not be." The E.M.F. between A and B, which we shall call E′ to differentiate it from the E.M.F., E, at the poles of the battery, is when the galvanometer is unshunted.

$$E' = \frac{E}{R+G} \times \frac{G}{1} = \frac{E\,G}{R+G} \quad . \quad . \quad . \quad (1)$$

When the shunt is applied,

$$E' = \frac{E}{R + \frac{G\,S}{G+S}} \times \frac{G\,S}{G+S} = \frac{E\,G\,S}{S\,(R+G) + G\,R} \quad (2)$$

Now "H L" will easily see that there are cases in which equations (1) and (2) are equal—*i.e.*, when R equals 0; and also cases in which they are approximately equal—*i.e.*, when R is negligible in comparison with G. In such cases the E.M.F. at A and B will be practically unaffected, and the current will be the same in the galvanometer whether it is shunted or not.

To put the matter more exactly, the difference between equations (1) and (2), which equals

$$\frac{-E\,G^2\,R}{\{S\,(R+G) + G\,R\}\,\{G+R\}},$$

is the amount by which the E.M.F. is reduced on the addition of the shunt.

The currents in the galvanometer and shunt may be respectively found by dividing equation (2) by their respective resistances.

Now, it is usual in the "text-books" to say that a shunt applied to a galvanometer reduces the current $\frac{S}{G+S}$ times, and the student takes it that this means $\frac{S}{G+S}$ times the current flowing without the shunt. How far this is true can easily be shown.

The current in galvanometer unshunted is $\frac{E}{G+R}$, and if the shunt reduces this $\frac{S}{G+S}$ times, then the current when shunted should be

$$= \frac{E}{G+R} \times \frac{S}{G+S} = \frac{E\,S}{G^2 + G\,R + S\,(R+G)} \quad . \quad (3)$$

but we have shown in equation (2) that it really is

$$\frac{E\,S}{G\,R + S\,(R+G)} \quad . \quad . \quad . \quad . \quad . \quad (4)$$

It is evident that these equations can never be equal if G has any value, and can be only approximately equal if G is small in comparison with R. If G has not a negligible value, and it is absolutely necessary to reduce the current in it $\frac{S}{G+S}$ times, then the obvious remedy is to add a compensating resistance as well as a shunt. The value of the compensating resistance is $G - \frac{G\,S}{G+S} = \frac{G^2}{G+S}$, and I think "H. L." will see that this allows the E.M.F. between A and B to be varied to the desired extent, so that $\frac{E'}{G}$ will be $\frac{E'\,S}{G+S}$ times reduced on the application of the shunt.

No doubt "H. L." has taken the approximately true statement of the text-books as being absolutely correct, and finding those cases in which it is glaringly out has started "cussing 'em." But let the text-book authors answer for themselves.

Hoping the above remarks may be serviceable to "H. L."—
Yours, etc.,
J. SINNOTT.

Haverfordwest.

N.B.—In "H. L.'s" enquiry, under "equal deflection" paragraph, the E is invariable in the formulæ. It is the E.M.F. of battery taken at its poles.

HIGH-SPEED ELECTRIC RAILWAYS.

SIR,—In reference to the article by Mr. F. B. Lea in last Friday's paper, I would like to point out that there is no real disparity between the values found for the air resistance by Dr. Hopkinson and Mr. O. T. Crosby. The difference is due to the "skin friction" of the air on a long train. Though this is relatively a small quantity per square foot, we have in the case of a train with the given dimensions an area of 7,900 square feet exposed to its action. I have not the exact values to hand, but I know that this forms a large part of the resistance of trains, and it varies with the square of the velocity.—Yours, etc.,

CHAS. E. WOLFF.

Brook Cottage, Ockbrook, near Derby, January 6, 1894.

Rome.—It is reported that the cable supplying the Via Nazionale and the Corsa at Rome with the electric light was cut on Sunday.

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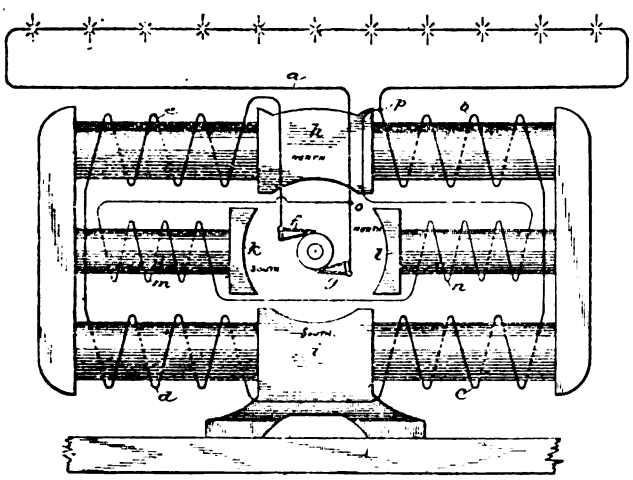
THE SCRIBNER CONSTANT-CURRENT ARC DYNAMO.

Mr. Charles E. Scribner, of the Western Electric Company, has recently devised an interesting method of avoiding sparking at the brushes of dynamos due to sudden changes of load, and described in a patent just issued. In this system the current built up in each coil while it is short-circuited is of the same direction and strength as that in the circuit of the current-producing coils into which it is introduced when the short-circuit is removed; that is to say, while each coil is short-circuited its current goes to zero, and then is built up to a certain extent, and by controlling this building up of the current in such manner as to make the current built up equal to that in the circuit of the coils into which it is introduced, objectionable sparking is avoided.



Scribner Constant-Current Arc Dynamo.

By reference to the accompanying diagram it will be seen that the main circuit, *a*, including the lamps, may be traced through the coils, *b c d e*, of the field magnets of the short-circuited coils, and thence through the pairs of brushes, *f g*. The poles, *h i*, are thus magnetised by these coils. In addition to these field magnets of the short-circuited coils there is provided the pair of magnets, *k l*, with the coils, *m n*; these coils are included in a shunt circuit between the points *o p*, which are connected with different sides of an arc light circuit. The magnets, *k l*, which have their coils included in the shunt between the points *o p* on different sides of the lamps are so placed with reference to the brushes and the revolving armature as to produce a field whose lines of force are cut by the current-producing coils. It is evident that as the number of lamps in the circuit is increased more current will be sent through the coils, *m n*; in other words, the increase of work to be done increases the field of the coils which produce the current to do the work, and *vice versâ*.

The poles, *h i*, are in position to produce a field which is cut by the short-circuited coils, and the windings, *b c d e*, are such that the circuit built up in the short-circuited coils is equal to the current in the circuit of the current-producing coils into which the short-circuited coils are introduced.

According to Mr. Scribner, between 50,000 and 60,000 ampere-turns of No. 16 wire upon poles which determine the E.M.F. of a dynamo of 1,000 to 1,200 volts maximum capacity will give the desired regulation. The size of the field should be so proportioned that this number of turns will have a resistance of from 500 to 600 ohms. The main fields may be varied to give the proper current in the short-circuited coil upon first building the dynamo, the number of ampere-turns necessary depending, of course, upon the character of the iron used and the shape of the pole-pieces of the main field cores. If the dynamo at 1,000 volts with the brushes clean gives a current higher than is desired, a reduction in the number of ampere-turns upon the magnets whose poles, *h i*, are placed over the short-circuited coils, can be made to bring the current to the desired strength.—*Electrical Engineer* (New York).

WAKEFIELD ELECTRIC LIGHTING.

The following is the report of Mr. Robert Hammond, M.I.E.E., upon the proposed establishment of municipal electricity works in this city.

1. Following your instructions I have pleasure in reporting to you upon the proposed establishment of municipal electricity works in your city.

2. I understand that since my interview with your General Purposes Committee, your Town Council have carried into effect their determination to apply for a provisional order under the Electric Lighting Acts, 1882-1888, and have chosen a compulsory area situated in the centre of the city.

3. I beg to lay before you the reasons why, in my opinion, it would be prudent on the part of your Corporation to carry out the provisions of the order and to lay down electricity supply works.

4. "Electricity supply" has completely emerged from the experimental stage, and is now firmly established as a sound and remunerative business, the works which are at present in operation absorbing a capital of over 4½ millions.

5. To give you a clear idea of the present position of electricity supply in the United Kingdom, I set forth a tabulated statement of the electricity works at present in operation, under statutory powers, the capital invested being set out and a discrimination made between those works situated where the gasworks belong to the corporation and where they belong to a company. This table is not confined to works belonging to local authorities, because the amount of capital already invested in the industry by private enterprise, as indicating the opinion of capitalists, has a very important bearing on the question of the soundness of the electricity supply industry.

TABLE A.—Electricity Works (holding statutory powers) in Actual Operation in the United Kingdom. Statement of Capital Invested.

Date of starting supply.	Name of place.	Supply by companies.		Supply by local authorities.	
		Where gasworks owned by a company.	Where gasworks owned by local authority.	Gasworks owned by a company.	Gasworks owned by local authority.
		£	£	£	£
1882	Eastbourne	37,119	—	—	—
1883	Hastings	20,745	—	—	—
1884	Liverpool	186,439	—	—	—
1887 to 1889	The Metropolis Companies	3,323,552	—	—	—
	Local Authority, St. Pancras	—	—	100,000	—
1888	Sheffield	20,000	—	—	—
1889	Bournemouth	38,625	—	—	—
,,	Bradford	—	—	—	69,800
,,	Bath	38,340	—	—	—
,,	Taunton.....	—	—	16,000	—
1890	Newcastle-on-Tyne	75,105	—	—	—
,,	Exeter	20,100	—	—	—
,,	Birmingham	—	70,000	—	—
,,	Chelmsford	10,000	—	—	—
,,	Chatham	20,000	—	—	—
1891	Brighton Corporation..	—	—	73,200	—
,,	Northampton	15,000	—	—	—
,,	Southampton	12,645	—	—	—
,,	Fareham	4,158	—	—	—
1892	Preston	53,025	—	—	—
,,	Dublin	—	—	40,000	—
,,	Hove	15,500	—	—	—
,,	Nelson	—	—	—	10,000
,,	Oxford	62,520	—	—	—
,,	Morecambe	4,781	—	—	—
1893	Aberdeen	—	—	—	20,000
,,	Blackpool	—	—	—	31,000
,,	Burnley	—	—	—	23,500
,,	Bristol	—	—	66,000	—
,,	Cambridge	23,180	—	—	—
,,	Derby	—	—	30,000	—
,,	Hanley	—	—	21,000	—
,,	Huddersfield	—	—	—	50,000
,,	Hull	—	—	35,000	—
,,	Kingston (Thames)	—	—	16,000	—
,,	Leeds	—	56,000	—	—
,,	Manchester	—	—	—	150,000
,,	Glasgow	—	—	—	100,000
,,	Dundee	—	—	—	30,000
,,	Norwich	14,226	—	—	—
,,	Scarborough	22,000	—	—	—
,,	Whitehaven	—	—	—	14,000
	Totals...	£4,017,060	£126,000	£397,200	£498,300

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6. It will be seen that the total capital invested at the present time in electricity supply works operating under statutory powers and actually in operation is £5,038,560, which is contributed as follows:

Owned by.	Capital invested.
Companies	£4,143,060
Local authorities	895,500
	£5,038,560

7. In only two cases where the gasworks belong to the corporation—*i.e.*, Birmingham and Leeds—have the local authorities allowed a provisional order to go into the hands of a company.

8. In addition to the electricity works already in operation, there are 12 new works for which contracts have been given out, and the amount of capital involved therein may be tabulated as follows:

TABLE B.—Electricity Works in Course of Construction in the United Kingdom.

Name of place.	Supply by companies.		Supply by local authorities.	
	Where gasworks owned by a company.	Where gasworks owned by local authority.	Gasworks owned by a company.	Gasworks owned by local authority.
	£	£	£	£
Burton-on-Trent	—	—	—	25,000
Cardiff	—	—	32,500	—
Dewsbury	—	—	—	25,000
Ealing	—	—	25,000	—
Hampstead	—	—	25,000	—
Lancaster	—	—	—	25,000
Londonderry	—	—	15,000	—
Leicester	—	—	—	50,000
Oldham	—	—	—	27,000
Portsmouth	—	—	56,385	—
Richmond	20,000	—	—	—
Worcester	—	—	39,109	—
Totals	£20,000	—	£192,994	£152,000

9. It will be seen that in the case of these new works, none are being erected by companies in localities where the gasworks belong to the corporation, and that the amount of new work which companies have in hand bears only an insignificant proportion—5·79 per cent.—to that of local authorities:

Owned by.	Capital invested.
Companies	£20,000
Local authorities	344,994
Total	£364,994

which sums added to those given above (Table A) result as follows: Tables A and B (combined).

Owned by.	Capital invested.
Companies	£4,163,060
Local authorities	1,240,494
Total	£5,403,554

10. In addition, however, to the capital involved in works in actual operation and in course of construction, large sums have been voted by town councils for the laying down of electricity works, and specifications are being considered with a view of contracts being given out. These sums may be summarised as follows:

TABLE C.—Electricity Works Decided Upon (but contracts not yet given out) in the United Kingdom.

Supply by companies.		Supply by local authorities.	
Where gasworks owned by a company.	Where gasworks owned by local authority.	Where gasworks owned by a company.	Where gasworks owned by local authority.
£	£	£	£
35,000	Nil.	502,972	373,000

Again, note the great display in value—3·9 per cent.—of the new works decided upon by companies and by local authorities:

Owned by.	Capital invested.
Companies	£35,000
Local authorities	875,972
Total	£910,972

Reaching the grand total of Tables A, B, and C (combined).

Owned by.	Capital invested.
Companies	£4,198,060
Local authorities	2,116,466
Total	£6,314,526

11. In addition to the above there are some 43 places in which electricity works are projected, but in which no final decision has been come to. These works, if carried out, would involve a further expenditure of over £750,000.

12. The above figures are significant. They indicate: (1) That there is a consensus of opinion in favour of the establishment of electricity supply works; (2) that though the bulk of the pioneer work has been done by private enterprise, the newer works are almost all being undertaken by local authorities; (3) that with only two exceptions has any local authority owning the gasworks sanctioned the granting of statutory powers to a company.

13. It is a matter of importance in the cases where provisional orders have been sanctioned by corporations owning their gasworks, to consider the terms of purchase that have been arranged. The Leeds terms are as follows: The Leeds Corporation has the right of taking over the works and business of the company: (A) At any time prior to July, 1901, by the issue to the company of such an amount of Leeds Corporation stock as will produce by the interest or dividends thereon an annuity of 5 per cent. per annum upon the sum expended by the company upon the undertaking and chargeable to capital account, and also the payment to the company of a sum equal to the aggregate amount of a dividend of 5 per cent. per annum on the said capital expenditure, less the aggregate amounts of the dividends declared by the company up to the date of purchase. (B) At any time from July, 1901, to July, 1912, by the issue to the company of such an amount of Leeds Corporation stock as will produce by the interest or dividends thereon an annuity of 5 per cent. per annum upon the capital account of the company. N.B.—For instance, if at the date of such purchase the capital so expended were £50,000, the company would receive sufficient Corporation stock to produce £2,500 per annum, the market value of which is now about £80,000. (C) At any time between July, 1912, and July, 1922, either on the above-named terms (B) or upon the Corporation paying the company the then value of the undertaking in accordance with Section 2 of the Electric Lighting Act, 1888, together with such additional sum as may be determined by arbitration to be the value of the goodwill of the undertaking. (D) After the expiration of July, 1922, or at the end of every subsequent period of seven years, either on the terms of (B) or upon the Corporation paying the company the then value of the undertaking, in accordance with Section 2 of the Electric Lighting Act, 1888; but the option of purchase on the terms of (B) ceases in 1933.

14. From the above it will be seen that where a Corporation permits a company to obtain a provisional order, the Corporation has only the right of the acquisition of the undertaking, prior to the expiry of the time allotted by Parliament, under terms extremely favourable to the company.

15. Turning to the question of the financial results of the works already in operation, it would, of course, be idle to expect that they should show, in the very early days of their working, the same results as may be expected from concerns long established and with settled businesses. The following table, however, shows the margins, on the right side, between costs of working and revenue as exemplified by the 1892 balance-sheets of electricity works:

Name of works.	Margin between total costs and revenue.	On a capital of	Per cent. of margin to capital.
	£	£	
Birmingham	3,488	70,000	4·98
Bradford	1,476	34,243	4·31
Charing Cross	10,247	200,900	5·10
Chelsea	4,319	80,585	5·36
Eastbourne	1,746	37,119	4·70
House-to-House	2,836	76,795	3 69
Kensington	10,327	154,400	6·68
Liverpool	15,993	186,409	8·58
Metropolitan	18,168	549,741	3·30
Newcastle and district	2,140	33,240	6·43
Newcastle-on-Tyne	2,300	40,699	5·65
St. James	18,329	200,000	9·11
St. Pancras	2,576	91,269	2·82
Westminster	14,508	370,000	3·92
Brighton	2,229	52,563	4·24
	£110,682	£2,177,963	5·08 % (average)

16. It will be noticed that in almost all the above cases there is sufficient margin between the costs of production and the revenue to provide for the annual sinking fund required to repay the electric light loan, if the supply were in the hands of the local authority.

17. The General Purposes Committee of the Birmingham Town Council have, however, just reported "that at present at all events, the profits made from the supply of electricity are inconsiderable"; but they overlook the highly-important fact that the bulk of the works in operation are only in the initial stage, and as they develop, and the demand increases, they will work at much cheaper costs, and show much more substantial margins between costs and revenue.

18. The active increase in the demand, however, will largely depend upon the possibility of being able to directly compete with gas in price, for the greater number of householders, as a rule, are compelled by stern financial necessity to give the preference to the less desirable article on account of its cheaper price.

19. At present electricity is being supplied in various towns at

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prices which compare with gas at from 2s. 6d. to 4s. per 1,000ft., and at Wakefield if 6d. per unit be fixed upon as the charge, it will compete with gas at 3s., if 7d. per unit 3s 6d., per 1,000ft.

20. It must be remembered, however, that these prices are on the basis of a limited production, while they are compared with gas produced on a large scale. It is fair to assume that when electrical energy is produced on the same scale as gas it will directly compete with it in price.

21. One important feature in this connection is the series of improvements which are certain to occur in the incandescent lamp, on a par with those that have from time to time taken place in gas-burners. When the incandescent lamp was first invented it required, with a life of about 1,000 hours, according to the size of lamp, five to six watts for one candle of light. Now it requires three watts to 4½ watts for one candle of light. The manufacture of incandescent lamps in the country is now thrown open, and the German makers are offering short-lived lamps to consume only 2½ watts per candle. When, by various improvements in the filament, less electrical energy is required to produce each candle of light, without a curtailment of the life of the lamp, the comparison between the cost of electrical energy and gas as illuminants will become more and more favourable to electricity. If for the same amount of light a consumer should only use 100 units, at 6d. per unit, where he now uses 200, electricity to him will practically only cost half its present price.

22. Again, in the production of electricity at present there are no by-products, but there is a large margin for the utilisation of the electrical plant for purposes other than lighting. The work of generating electricity for lighting is only equivalent to about two and a half hours' use of the plant daily all the year round. If a full use of the plant during the remaining 21½ hours of the 24 were discovered, it would be possible to make a profit out of selling electricity at even less than 2d. per unit. This would correspond, say, to less than 1s. per 1,000ft. for gas. The advantages which gas derives from by-products will probably accrue to electricity in time through by-uses of the plant. However small, therefore, be the margin of profit at the beginning, there is a probability of large profits being made by degrees, without adding to or altering the plant.

23. To sum up, it may be contended that the business of electricity supply is based at the present stage on sound commercial lines, and that its future is all in the direction of cheaper costs.

24. The question, then, for the city of Wakefield to decide is whether it should keep the business in its own hands or sanction its transference to a company. If the latter course be adopted the Electric Lighting Acts provide for a 42 years' tenure by the company, and even if an arrangement be made for an earlier purchase, it is manifest that the Corporation will be called upon to pay a pretty heavy bonus, as already instanced by me in the case of Leeds.

25. It is, however, in any case manifest that the ratepayers will be better off if supplied by the Corporation than by a company, because the price charged by a company must cover the cost of administration by directors and also a provision of a good dividend to shareholders, whereas in the case of supply by the Corporation there will be no directors to pay and no fat dividends to provide. The local authority will, I presume, be able to borrow the capital necessary at 3 per cent., a rate that would, of course, not satisfy the shareholders in a company.

26. Again, if the Corporation were to sanction the transfer of its provisional order to a company, the first step of the company would be to select a compulsory area, limited in extent, but comprising the choicest portion of the town, from the electric lighting point of view. Ratepayers inside this area would be able, by the use of the electric light, to make their places of business more attractive, to the detriment probably of the ratepayers outside, who cannot demand a supply for two years, and can then only obtain it under onerous conditions of guarantee, etc.

27. In the hands of a company the growth of the undertaking must necessarily be slow. The shareholders, believing in quick returns, insist upon immediate and good dividends as the precursor to any enlargement of the capital account. The business is therefore often cramped for capital from the beginning, and the unfortunate ratepayers in the "outside area" are left in the lurch.

28. Your Corporation could afford to take wider views. If the business be in itself sound, your aim will be to develop it on an extended basis as rapidly as possible. You could afford to make "capital extensions" without waiting for a 5 per cent. or 6 per cent. return upon the work in the compulsory area; your principal aim being, with due regard to permanent profitable results, to extend the benefit of electricity supply throughout the whole of the district under your control.

29. Again, your Corporation has a strong interest in the advancement of any scheme which tends to improve the sanitary conditions of your city, and though the advantages of the electric light are now almost generally acknowledged, I venture to summarise the conditions which attach to the perfect light, and which are fulfilled by the incandescent light—*i.e.*, it must (1) not feed on the air; (2) add no noxious fumes to the air; (3) give off no appreciable heat; (4) be free from danger of causing fire; (5) not injure a tradesman's stock; (6) do no damage to ceilings, furniture, etc.; (7) not injure the sight; (8) be quite reliable; (9) not escape; (10) be absolutely free from danger to life or limb; (11) be convenient, capable of being measured and economised, and arranged artistically.

30. I may mention another advantage attaching to the supply being in the hands of the corporation—viz., that the corporation is itself a good customer in the direction of public lighting. The greatest inconvenience in electricity supply is that arising from the fact that the demand ceases almost entirely at bedtime, and it greatly assists economical working if the load can be continued far into the night, and the public lighting to a certain extent provides for a continuance of the load.

31. I am, in the above remarks, taking for granted that the Corporation will desire, certainly as the works develop, to adopt electric lighting in the public streets. The incandescent light, which is used in the houses, is not suitable for street-lighting, and I should recommend the adoption of the arc light. An arc light, however, gives a very much more brilliant light than the best gas-lights, and the result of introducing the arc light would therefore be to give a very much more brilliant illumination to the streets, resulting in an increased security both to persons and property, it being the experience of cities where the arc lighting has been introduced that crime has been reduced and the number of accidents minimised.

32. In the case of adopting arc lighting extensively, it is well to have the lamps arranged upon two circuits, so that each alternate lamp can be turned out, say, at 11 o'clock in the evening, the extinguishing being done by the movement of a switch at the central station, without involving the cost of a lamp-lighter. Street-lighting is, in my opinion, an extremely valuable accompaniment to incandescent lighting, as the streets in which the electric lights are placed are of course far better illuminated and lead to the better illumination of neighbouring premises. They also act as an attraction to people living in neighbouring places, and may be relied upon to generally increase the business of the place.

Selection of Site.

33. The most important point to be first considered is that of site. The nearer the generating station is to the centre of supply the better, and I have carefully considered the advisability of adopting the site owned by your Corporation at the top of Kirkgate.

34. As it is possible, when dealing with the problem of electricity supply, to lay down the initial works on a comparatively small scale and to gradually add plant, unit by unit, as the load increases, it is evident that though a small site may be suitable at the start, it is of vital consequence to provide good room for extensions, as if the undertaking proved a great success and the enlargement of the works could not be effected on the site originally chosen, it would be necessary to lay down second works—manifestly a very extravagant method of proceeding.

35. The Kirkgate site is very limited in extent, and I do not therefore recommend that the works should be erected on it, or, indeed, on any other site where ample room for extensions is not available. I have visited the sites which lie at the outskirts of the city, and I find that both the site at the proposed sewage works and the site at the sanitary depôt are suitable. I have based my estimate upon the establishment of the works upon the sewage site.

System of Supply and Estimate of Cost.

36. The next point to be considered is that of system. There is not a wide difference between the various systems of generation of electricity, but there are many systems of distribution of electrical energy for house-to-house lighting by means of incandescent lamps. The filaments within these lamps are made to stand only low pressure, and whatever system of generation or distribution may be adopted, the electricity must finally be delivered to the lamps at low pressure—*i.e.*, low tension. Distribution at low tension throughout, however, involves the use of a large quantity of electricity, since the electrical energy required for lighting is the product of pressure and quantity. For instance, 1,000 lamps, requiring each 35 watts of electrical energy, use a total of 35,000 watts, which may be brought from the generating works in the form of

Pressure.		Quantity.	
2,000 volts	.....	17·5	amperes
1,000 ,,	.....	35	,,
500 ,,	.....	70	,,
300 ,,	.....	116·6	,,
100 ,,	.....	350	,,

The size of the mains is governed by the quantity of electricity to be conveyed and the distance to which it has to be conveyed. It is manifest, therefore, that distribution by means of low tension necessitates much larger mains than distribution by means of high tension, and in scattered areas the length of the mains practically prohibits low-tension distribution.

37. In Wakefield, however, the city covers a compact area, the bulk of the lighting being embraced within a radius of half a mile from a central point. This can very easily be coped with by means of a pressure of 200 volts (three-wire system). In order, however, to keep the size of the main within practicable limits it will be necessary to generate the electricity at high tension and to bring it at high tension to the distributing station in the city, say at Kirkgate Corner or at any other suitable site which may be available. This distributing station would be in charge of an attendant, and from it the electricity would be distributed by means of cables radiating throughout the city.

38. The cost of a 3in. culvert and the cable requisite for bringing sufficient electricity from the sewage site to maintain, say, 6,500 incandescent lamps burning simultaneously would be £1,452, the cable being of section large enough to provide for a loss of electrical energy on route of only 5½ per cent. at full load, the loss dropping down to zero as the load diminishes. The annual monetary value of this loss can be estimated by calculating the total cost of production, and taking this at about £2,000, the 5½ per cent. would work out £110. As, however, the 5½ per cent. loss only occurs at full load and dwindles to nothing at no load, it would be safer to take the average at 1 per cent., or, say, £20. To this must be added the amount of the annual charge involved by

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the capital outlay. Presuming that the city borrows at 3 per cent. and arranges to pay off the electric lighting loan in 25 years, the annual charge in respect of the above named £1,452 would be £83. 10s.; cost of the electrical energy lost on the route estimated at £20; total, £103. 10s.; which represents the annual cost of the distant site.

39. As a set-off against this annual charge there are many important advantages connected with the distant site: (1) It is of such a size that the city will not be compelled, as many have been, to choose cramped up and unsuitable driving engines; (2) water will be available for condensing, the effluent sewage being probably available; (3) coal will be obtainable at a cheaper rate than if delivery had to be made into the centre of the city; (4) supervision of the borough officials will be facilitated by the proximity of the electricity works to the sewage works.

Size of Works.

40. I have already pointed out that in coping with the problem of electricity supply, the plant can be laid down in instalments to meet the actual requirements of the city. In any case, whatever the size of the plant, it is desirable to divide it into units, as only for about half an hour daily is the full capacity of the plant required. On the other hand, too small a sub-division is undesirable, as small engines do not work so economically as large ones.

41. I recommend that the unit should not be smaller than 150 i.h.p., driving an alternator dealing normally with a maximum load of 75 kilowatts—*i.e.*, capable of lighting 2,500 incandescent lamps all burning at one time, permitting the fixing of about 3,750 lamps on the premises of the consumers.

42. I estimate that the cost of works containing this size unit would be £12,000, which figure covers all engineering charges and a fair margin for contingencies. It includes: (1) Suitable building, to cost with the foundations of the plant, £1,500; (2) Lancashire boilers, with feed-water heaters, and all necessary steam and exhaust pipes; (3) horizontal slow-speed engines; (4) alternators; (5) switchboard; (6) condensing arrangements; (7) 2,100 yards 3in. cast-iron culverts; (8) 8,400 yards of well-insulated high-tension cables (*i.e.*, four cables of 2,100 yards each; this sub-division providing for easy manipulation, testing, and repair, to connect the generating with the distributing station, and of a size capable of carrying the electricity generated by three such plants; (9) plant of distributing station; (10) 2,850 yards of well-insulated triple concentric low-tension distributing mains, with all requisite feeders for three such plants; (11) 10 arc lamps, lamp-posts, and switches.

43. But it must be borne in mind that the costs of working a large plant are, in the main, the same as those incurred in working a small plant, the only additional expenses of working a large plant as compared with a small one being that of the extra coal and the wages of additional engine-drivers and stokers and (with mechanical stokers) up to three units of plant there is hardly any additional wages at all. Unless, therefore, it is of vital importance to minimise the capital expenditure, it is hardly wise to limit the first works to one unit of plant.

44. The cost of two 150-i.h.p. plants with a capacity of 5,000 lights burning at once, and, say, 7,500 lights installed, would be £15,750, including 15 arc lamps, posts, switches, etc., for public lighting, and £2,250 for the buildings, foundations, etc.

45. The cost of three such plants with a capacity of 7,500 lights burning at once or, say, 11,250 lights installed, would be £19,500, including 20 arc lamps, posts, switches, etc., for public lighting, or for letting out to tradesmen, etc., and £3,000 for the buildings, foundations, etc.

46. For economically dealing with the low loads between 11 p.m. and sunset the next day, I recommend the use of a small day load self-contained plant of 50 i.h.p., the cost of which with necessary additions to switchboard would be £650. This sum must therefore be added to each of the foregoing estimates.

47. Summarising the foregoing we have:

(A) Plant for 2,500 lights burning at once or 3,750 installed, costs	£12.000
(B) Plant for 5,000 lights burning at once	15,750
(C) Plant for 7,500 lights burning at once	19,550
(D) Day load plant for 800 lights burning at once	650

Revenue.

48. In order to arrive at a just appreciation of the probable revenue, an estimate must be made of the probable consumption of electricity in the city of Wakefield. This can, of course, only be arrived at by comparison with other places.

49. The following is a statement of the consumption of electricity per lamp fixed which obtains in some of the central electricity works already in operation:

Name of town.	Annual consumption per lamp fixed.
Bradford	18·45
Birmingham	18·09
Brighton	19·51
Bournemouth	18·20
Exeter	19·14
Southampton	22·53
Liverpool	27·49
Northampton	10·94
Leeds (not yet ascertained, the supply having only been started in May last)	—
	154·35
Average of eight places	19·29

To be well within the mark, I think that the revenue may be calculated in Wakefield on the basis of a consumption of 18 units per lamp fixed.

50. The next step must be to determine what percentage of lamps may be fixed in excess of the maximum which the station can produce. In some localities it is found that out of every 100 lamps fixed there are never more than 50 in use at any one time, and in these places it is, of course, quite safe to instal throughout the town just double the number of lamps which the station can produce at any one time. In Wakefield I gather that the bulk of the demand will come from business premises, and under these circumstances it will probably be found that out of every 100 lights fixed 66 will be all on at one time.

51. Having decided that 50 per cent. more lights may be fixed than the maximum capable of being produced at the works, it will be for you to decide to what extent you will provide for reserve plant.

Plans.	Normal.			
	Capacity in horse-power.	Capacity in kilowatts.	Capacity with lights all on at once.	Permitting of fixing 50 % in excess.
A + B	200	100	3,300	4,950
B + D	350	175	5,800	8,700
C + D	500	250	8,300	12,450

If, however, all the above lights were fixed, there would be absolutely no margin of reserve. On the other hand, it must be borne in mind that the time of top load only lasts for about half an hour daily, and the risk involved in running the plant to its full capacity during half an hour daily is only very slight, and as the plant which I have specified is of first-class quality there would be a minimum risk of breakdown, especially as the plants could in an emergency be run with ease fully 20 per cent. beyond their normal capacity.

52. According to the number of plants the following would be the revenue on the basis of the consumption of 18 units per lamp per annum arrived at before.

Plan.	Lamps fixed.	Annual consumption of electrical energy per lamp in B.T.U.	Total annual consumption of electrical energy in B.T.U.	Revenue at 6d. per unit (equal to 3s. per M. for gas).
				£
A + D combined	4,950	18	89,100	2,227
B + D ,,	8,700	18	156,600	3,915
C + D ,,	12,450	18	224,100	5,602

Cost of Working.

53. The staff required for working the station under the various plans would be:

Officer.	Duties.	A and D combined.	B and D combined.	C and D combined.
		Per annum £	Per annum £	Per annum £
Engineer	Complete management of the works	200	200	200
Junior electrician	In charge of switchboard at heavy load	52	52	65
Ditto	In charge at light load	52	52	65
Cleaner	Cleaning the plant, and in charge at lightest load	52	52	52
Engine-drivers	Driving engine at heavy load	91	91	182
Engine-driver	Stoking and running engine at light load	91	91	91
Stoker	Heavy load	65	65	65
Lads	Odd jobs	26	52	52
Attendant	At sub-station	65	65	65
Ditto	Ditto	—	65	65
		£694	£785	£902

To which it would be wise to add for outside work:

Jointer	£120	£120	£120

It being presumed with regard to the clerical work that it will be done by the present borough officials.

54. In addition to the staff there will be the following expenses:

Coal, 600 tons, 1,050 tons, 1,500 tons at 9s.	£270	£472	£675
Oil, waste, etc.	90	150	200
Repairs	150	250	350
Water	nil	nil	nil
Insurance	20	30	40
	£530	£902	£1,265

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55. Making a total cost of:

Wages and salaries on station.....	£694 ...	£785 ...	£902
Outside	120 ...	120 ...	120
Materials, repairs, etc.	530 ...	902 ...	1,265
	£1,344 ...	£1,807 ...	£2,287

56. On the above basis the works' costs come out as follows:

Plans.	Production in units.	Cost per unit in pence.
A+D combined	99,100	3·62
B+D ,, ...	156,600	2·79
C+D ,, ...	224,100	2·45

On reference to the table of costs which appears in *Lightning*, it will be seen the above estimates are not theoretical, but are based on experience of works' management, and that lower works' costs prevail in some electricity works producing greater outputs.

Name of company.	Output, B.T.U.	Works' cost per unit. Pence.
Newcastle and District Electric Light Company .	290,469	2 90
Newcastle-on-Tyne Electric Light Company.....	335,141	2·52
Birmingham.....	214,088	2·30
Bradford	401,540	1·96
Liverpool	796,281	1·86

and it may therefore be conceded that as the load on the Wakefield central station increases, the works' costs per unit would gradually decline.

On the other hand, it may be pointed out that in places where the economical system proposed for Wakefield is not in use, higher works' costs prevail.

Name of company.	1892 output, B.T.U.	Works' costs per units, pence.
Southampton	35,537	5·64
Northampton	38,293	4·40
Eastbourne	107,842	4·67
Bournemouth	132,343	4·57

The London stations are omitted in both comparisons as affording no guide to working in Wakefield.

The plan proposed by me appears therefore to entail very cheap costs of working, and if adopted by you, will, I feel certain, place you in the position of having one of the cheapest worked stations (of its size) in England.

The actual financial results to the Corporation would be as follows:

Plans.	Capital outlay.	Margin for providing sinking fund.	Percentage of margin on capital outlay.
A and D combined	£12,650 ...	£883 ...	7 per cent.
B and D ,, ...	£16,400 ...	£2,108 ...	12 ,,
C and D ,, ...	£20,200 ...	£3,315 ...	16 ,,

As, however, the working of the four plants at the time of the top load would leave no margin of reserve, the more prudent plan would be, if the capital outlay under plans C and D be incurred, to keep on the 150-h.p. plant in reserve and, at the time of the top load, to run the three remaining plants 20 per cent. above their normal capacity.

This would yield the following results:

Plan.	Capital outlay.	Production, units.	Costs of working	Revenue B and D combined + 20%.	Margin.	Percentage on capital.
C and D combined	£20,200	187,920	£1,950	£4,698	£2,748	13½%

ARC LIGHTS.

I have made all my calculations on the basis of an incandescent plant. If, however, as suggested by me, arc lights are adopted for public lighting, the cost of working same would be 1½d. per hour, if charged to the public lighting authority at 3d. per unit, which would fully cover the cost, in consequence of the prolonged number of hours of burning. Every arc light would take up as much electrical energy as 15 incandescent lights. I submit plan of the proposed central station, and in conclusion, I beg to say that if there are any points upon which the Electric Lighting Committee would like to confer with me, I shall be happy to keep any appointment that they may fix.

Bermondsey.—Last week the General Purposes Committee of the Vestry recommended that, for the more efficient lighting of Spa-road between Alscot-road and Grange-road, the present lamps should be shifted. After Mr. Paddon had moved the adoption of the recommendation, Mr. Tyler said that he thought this might be an opportune moment to consider the advisability of lighting the baths, Town Hall, and library with electricity. The Chairman said the question would involve considerable expenditure, and Mr. Ecroyd, one of the Library Commissioners, said they (the Commissioners) were not in a position to spend any money on electric lighting, seeing that at the end of the financial year they would have a deficiency of £100. No action was taken on Mr. Tyler's suggestion, and the motion was carried.

COMPANIES' REPORTS.

FOWLER-WARING CABLES COMPANY, LIMITED.

Directors: Wm. Fowler, Esq. (chairman), Walter Chamberlain, Esq., R. W. Eddison, Esq., George Fleming, Esq., the Lord Medway, Geo. F. Smart, Esq.

Report to be presented to the shareholders at the fifth ordinary general meeting, to be held at Victoria-mansions, 32, Victoria-street, Westminster, S.W., on Friday, January 12, 1894.

The directors beg to submit herewith their fifth annual report. As will be seen on reference to the profit and loss account appended, the directors have passed their fees for this year to the credit of this account, which thus shows a net profit of £1,990. 5s. 3d. Out of this profit the Board proposes to write £1,329 off the value of shares in other companies which now stands in the balance-sheet at £2,115, thus reducing this item for next year to £786, at which price they may safely be left for the present, and to carry forward the balance of £661. 5s. 3d. to the credit of next year. These shares in other companies were taken in part payment of contracts, and practically represent the profit on cables supplied. The directors believe that they will earn dividends, and become saleable at par or over in due course, but in the meantime they deem it desirable to reduce the estimated value. On turning to the balance-sheet, shareholders will notice that the directors have placed the whole of the fees, hitherto credited, but not drawn by them, to the credit of that account, and they have thus been able to strike out the balance of loss as it appeared in last year's balance-sheet, and to write off £1,209. 4s. 10d. from the preliminary expenses. No allowance has been made for depreciation of plant and machinery, but all has been fully maintained and repaired from revenue. The stock has been taken with great care, and valued throughout at or below cost. The year has been one of great depression in financial and commercial circles, and all who could have held back orders, as far as possible, for better times, but the Company's business has continued to increase nevertheless, the sales being considerably in excess of last year, whilst the gross profits have, on the whole, and notwithstanding severe competition, been well maintained. In 1892, by circular, and again in their report of last year, the directors pointed out that the capital of the Company was insufficient for its immediate requirements and altogether inadequate to any large increase; they therefore made a temporary issue of £10,000 in 5 per cent. debentures, repayable in September, 1894. With the exception of £1,000 taken by one shareholder, the whole of this amount was either subscribed or guaranteed by directors. In view of the immediate necessity of providing additional capital to meet the growing business of the Company, and to pay off the debenture debt, the directors are negotiating for a fresh issue of £25,000, on debentures to be secured against the general assets of the Company, which in the meantime have largely increased, and afford, in the opinion of the Board, ample security for such an issue. Meanwhile, the directors are still confident that, with sufficient capital and ordinary fortune, the Company's affairs must continue to improve. The general manager's report is appended. The retiring directors are Lord Medway and Mr. Geo. F. Smart, both of whom are eligible, and offer themselves for re-election. The auditors, Messrs. Cooper Bros. and Co., also retire, in accordance with the articles of association, but offer themselves for re-election.

General Manager's Report.—The financial year with which this report deals has seen many further extensive applications of our cables, and we have had a considerable share of the work which has been carried out, but there has been a decided depression in our business, and in telephony, particularly owing to the fact that the replacement of overhead by underground conductors, which is proceeding so actively in every other country in Europe, has been in England very greatly deferred. Everything, however, indicates an early extension of telephonic enterprise, and, as our cables have already secured a leading position, such extension cannot fail to beneficially affect the Company. In all systems of electrical supply of any magnitude, and especially in the municipal lighting stations now spreading all over the country, the cost of the cables forms a very large proportion of the total expenditure, and it is of the first importance that the highest efficiency should be assured. In the competitive battle which wages round these large contracts, some of the older companies enter with a much larger record; we have, notwithstanding, secured several important municipal contracts, and wherever we have had the opportunity, we have at least equalled the best of our rivals' work. Only time is necessary to enable us to equal their records. Our customers among the engineers who carry out the wiring of buildings for the electric light have largely increased during the past year, and a number of extensive factories in this country and abroad have been entirely wired on our system. It is in this branch, however, that we are hampered by the most serious of our difficulties, and it is often impossible to secure the adoption of our lead-covered wires for work of this class. Indiarubber-covered wire, while more expensive, and, we believe, less efficient and permanent than lead-covered wire, is still more economical to fix and manipulate, and it is to be regretted that we have not been able fully to meet the demand for this wire. I hope, however, that we shall soon be able to do so. Meantime, the best methods of overcoming the difficulties in the application of lead-covered wires to small installations have been studied, with a large measure of success. The plant at Woolwich has been most carefully maintained and considerably added to. It has been our aim in the development of this business to closely apply the results of

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the most recent discoveries in those branches of applied science which have any bearing on our work. In competitive trials against other systems the high efficiency of our manufactures has been repeatedly established. Our progress has not been so rapid as some anticipated, but it has been considerable, and it has been on such safe and firm lines that we have every justification for confidence in the future. ALFRED E. MAVOR, General Manager.

BALANCE-SHEET, SEPTEMBER 30.

				£	s.	d.
Capital authorised :						
40,000 shares of £5 each	£200,000	0	0			
Issued :						
20,000 shares of £5 each, fully paid	100,000	0	0			
300 founders' shares issued as fully paid to vendors	1,500	0	0			
				101,500	0	0
Five per cent. mortgage debentures charged on the undertaking, part of £10,000 authorised				5,500	0	0
Note.—£4,500 have also been issued to secure a loan (guaranteed by the directors) included with creditors.						
Creditors				12,711	19	7
Profit and loss—Profit, as per last account	£1,990	5	3			
Directors' fees, charged in previous accounts, not waived by them	4,000	0	0			
	5,990	5	3			
Deduct—Loss, as per last account £2,790 15 2						
Written off preliminary expenses 1,209 4 10						
	4,000	0	0			
				1,990	5	3
Liability on bills receivable discounted	£1,614	15	10			
				£121,702	4	10

Cr.	£	s.	d.
Cash at bankers and in hand	1,231	9	0
Debtors	11,667	15	7
Stock	29,149	14	3
Office furniture in City offices and in factory	644	4	10
Shares in other companies at cost	2,115	0	0
Debenture	50	0	0
Machinery and plant as per last account, September 30, 1892 £16,941 6 1			
Additions during the year 1,761 0 2			
	18,702	6	3
Works and buildings—Outlay as per last account, Sept. 30, 1892 £14,781 9 2			
Additions during the year 265 15 2			
	15,047	4	3
Patents and goodwill	41,000	0	0
Preliminary expenses—As per last account £3,303 15 6			
Less amount written off 1,209 4 10			
	2,094	10	8
	£121,702	4	10

PROFIT AND LOSS ACCOUNT YEAR ENDING SEPT. 30, 1893.

Dr.	£	s.	d.
Directors' fees (£2,000 waived)	—		
Rent, rates, taxes, and insurances	2,315	17	2
Office and general expenses, advertising, and fees on patents	1,293	17	8
Interest on debentures	292	2	10
Balance—Net profit for the year ending September 30, 1893, carried to balance-sheet	1,990	5	3
	£5,892	2	11

Cr.	£	s.	d.
Gross profit on cables, after deducting salaries, maintenance of machinery, and other expenses	5,887	0	11
Transfer fees	4	2	6
Interest on debentures		19	6
	£5,892	2	11

BUSINESS NOTES.

Reading.—A large electric lighting scheme is proposed to be undertaken by a local company.

Great Northern Telegraph Company.—For the month of December the receipts were £20,800.

Buxton.—The Local Board have decided, in connection with their provisional order, to expend £10,000.

Western and Brazilian Telegraph Company.—The receipts for the week ended January 5 were £3,037.

Wigan.—The Library Committee have suggested the introduction of the electric light in the free library buildings.

Liverpool Overhead Railway.—The traffic receipts of this railway for the week ending 7th inst. amounted to £688.

Howth.—The subject of oil or electric lighting is under consideration in this district, which is situated near Dublin.

Vacancy for Pupils.—Messrs. Swinburne and Co., Broomhall Works, Teddington, have vacancies for two premium pupils.

Dalkeith.—The electric light has been fitted throughout the Dalkeith Hotel by Messrs. Fiford and Sons, of Southampton.

Bedford.—It has not yet been decided whether or not to transfer the Council's provisional order to the Bedford Electric Lighting Company.

Eastern Telegraph Company.—The receipts for the month of December were £55,579, as against £59,776 for the corresponding period of 1892.

Eastern Extension Telegraph Company.—For the month of December the receipts show a decrease of £5,389 as compared with the corresponding period of 1892.

Scarborough.—The Town Council have decided to bear the extra cost of laying underground wires for telegraphic communication with the branch post office at South Cliff.

Dover.—It is stated that there was a fair demand for the Dover Electric Light Company's shares, and that although they were not all applied for, the necessary capital will be forthcoming.

Woking.—Tenders are invited, by the 17th inst., for the lighting of the Woking station and Maybury ward for the Woking Local Board. Tenders to be sent to Mr. Robert Mossop, clerk, Woking.

Portsmouth.—The Electric Lighting Committee of the Town Council have been authorised to connect the mains with the technical school in Arundel-street, and with the branch library at Southsea.

Froggatt's Inventions Syndicate, Limited.—This Company has been registered, with a capital of £1,000 in £1 shares, to acquire and develop certain patents relating to methods of generating and storing electricity.

Electric Lighting of Edinburgh.—The Lord Provost's Committee of the Town Council have given instructions to advertise for estimates for the works in connection with the electric lighting of the city, the tenders to be lodged before the end of the present month.

Direct United States Cable Company, Limited.—This Company announces an interim dividend of 3s. per share, tax free, being at the rate of 3 per cent. per annum, for the quarter ending December 31, 1893, payable on the 24th inst., carrying forward £3,080.

Bray.—At last week's meeting of the Bray Township Commissioners, it was announced that the Electric Light Committee had recommended that the town clerk should be authorised to enter into correspondence with electric light contractors for purchase of plant, etc.

City and South London Railway.—The receipts of the Company for the week ending January 7 were £990, against £998 for the same period last year, or a decrease of £8. The total receipts for the first half-year of 1894 show a decrease of £8 over those for the corresponding period of 1893.

Sunderland.—In addition to the tenders mentioned in our issue of the 29th ult. as having been accepted, the tender of Messrs. Doulton and Co. at £807 for stoneware and pipes has been accepted, and also that of the British Insulated Wire Company for potential leads at 10½d. per yard, amounting to £90.

Port Beira Pier, Tramway, and Telegraph Company.—This Company has been formed with a capital of £150,000, in £1 shares, to acquire certain privileges and concessions granted by the Mozambique Company for the construction of piers and landing stages, tramways, telegraphs, and telephones in the port and town of Beira.

Walsall.—The Gas and Electric Lighting Committee of the Town Council have recommended that they should increase the amount of the loan to be asked for the proposed scheme of electric lighting to £21,900, so as to include the estimated value—viz., £2,250—of a part of the Wolverhampton-street Gasworks, intended to be used as the site of the electric generating station. The Mayor advised that the loan should be made £22,000, and this suggestion was adopted.

The Breaking up of City Streets.—Mr. Deputy Scott called the attention of the Commissioners of Sewers on Tuesday to the condition of some of the streets where the paving had been removed by the City of London Electric Lighting Company, and enquired whether there was no power to compel the company to replace the paving. Mr. King said that he thought the time had come when the Court should appoint some inspector to superintend the work of the company.

Stoke.—An electric light installation has been put up at the Stoke railway station, both in the goods yard and approaches. The platforms of the passenger station are now lighted by arc lamps. It is likely the offices and waiting-rooms at the station will soon be lighted by electricity. The North Stafford Hotel, the principal hotel in the district, has been equipped with an electric light installation, and in most of the rooms gas has been replaced by incandescent lamps.

Power Transmission in South Africa.—Messrs. H. Hanbury and Co., in their review of the South African market for 1893, quote the opinion of Mr. W. H. Furlonge, who was delegated by the United States Institute of Mines to report on the mines in the De Kaap district. Mr. Furlonge states that a great drawback to these fields has been the want of cheap motive power, but the electric installation of the Moodies, now approaching completion, will supply the mines of this concession with the necessary power at cost price.

Swansea Harbour.—The monthly meeting of the Swansea Harbour Trust was held on Monday, when the chairman moved

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the adoption of the report of the executive committee, which recommended that a contract for the working, maintenance, and renewal of the electric lighting machinery and plant be let to Mr. John S. Brown, at £649 per annum. As to the electric lighting, it was pointed out that the trust had in the past been doing the work themselves at a cost somewhat more than that for which Mr. Brown had contracted.

Tenders Wanted for Cheltenham.—As will be seen from our advertisement columns, the Corporation of Cheltenham invite tenders for supplying and erecting engines, dynamos, and boilers at their electric light station. A copy of the specification and any further information may be obtained on application to Mr. Joseph Hall, A.M.I.C.E., Municipal Offices, Cheltenham. Sealed tenders, on forms to be supplied, addressed to the Electric Lighting Committee, and endorsed "Tender for Machinery," are to be delivered at the Municipal Offices, Cheltenham, not later than Tuesday, the 23rd inst.

Bradford.—At a meeting of the Bradford County Council, after the reading of the minutes of the Sanitary Committee, Alderman Smith Feather asked the chairman if he had heard anything of the process for utilising the refuse at the destructors for the purpose of generating electricity. He understood there were gentlemen prepared to carry out the scheme on the "no cure, no pay" system. Mr. Louis Walker (the chairman) said that the system in use at Halifax did not belong to the Corporation, but was being worked by a private firm. He hoped soon to have a sub-committee appointed to enquire into the matter.

Extension of Premises.—The Electrical Installation Company, Limited, of 64, Victoria-street, S.W., inform us that, owing to increase of business, they are extending their premises, and are moving into additional offices at 66, Victoria-street, to which address their general office was transferred on the 8th inst. The company have started works in Pimlico, where they are manufacturing some of their specialities, *inter alia* being their new patent "Vauxhall" arc lamp, the "Britannia" automatic projector for marine and photographic purposes, and apparatus for the application of their system of electric heating.

Situations Vacant.—The Corporation of Wolverhampton invite applications for the post of draughtsman and assistant in the borough electrical engineer's office, at a salary of £90 per annum. Applicants must be capable draughtsmen, and have had technical training in electrical engineering. The Corporation also require applications for the post of working outdoor foreman and linesman, at a salary of £2 per week. Applicants must be steady men, and have had sound practical experience of the wiring and fitting of houses for electric light and power. and also of arc lamps and motors. Further particulars will be found in our advertisement columns.

New Installations.—Mr. E. R. Dolby, C.E., of 8, Princes-street, Westminster, acting as consulting electrician for Mr. S. V. Morgan, has recently completed an installation of 137 lights at 37, Harrington-gardens, South Kensington (Messrs. G. Trollope and Sons, contractors); also about 80 lights in the Economic Life Assurance Society's offices (Messrs. Baily and Grundy, Limited, contractors). He is now acting as consulting electrician for the lighting of Saratoga, Forest Hill, putting in a complete installation, consisting of a Crossley's Otto gas-engine, a Mather and Platt dynamo, E.P.S. cells, and the equivalent of 104 lights, Messrs. Strode and Co. acting as contractors.

Lighting at Belfast.—At a meeting of the Corporation last week some discussion arose on a proposal to adopt new standing orders prepared by the Council in committee. Mr. Masterton moved as an amendment that the order which provided that the Electric Committee should have charge of the superintendence and management of the electric works should be omitted, and that the words "and the electric works" should be added to the one referring to the Gas Committee. Alderman Connor seconded the amendment. Mr. Harrison, who opposed the amendment, said that, as electric lighting was a new department, it should be entrusted to men who had a thorough knowledge of electrical work. The original motion was eventually adopted.

Transmission of Power.—Mr. Dicey, a mining engineer at Barberton, has made the following suggestion to the Pigg's Peak Estate and Gold Mining Company: "I should wish you to consider whether it would not be advisable to increase your milling power to 60 stamps, as it is undoubtedly the quantity, not the quality, of this ore that will pay, the power to run the mill to be transmitted by electricity generated at the falls, thus reducing the working expenses in the mill to a minimum. The two turbines at the falls are capable of running 150 stamps, so the actual cost of working 60 stamps or more is, comparatively, the same as working 40. The turbines, fluming, and everything connected with the water power are in perfect order."

Eccles.—The Town Council last week adopted a resolution authorising the Tramways and Electric Lighting Committee to take such preliminary measures as might be advisable, with the object of carrying out the powers conferred upon the Corporation by the Eccles electric lighting order. Alderman Kendall urged that as the Corporation were bound to carry out the order, which was obtained in June last, within two years, they were forced to take the matter in hand to maintain their right, if they only proceeded to light a portion of the borough. The Corporation, he was told, could not supply 2,000 or 3,000 lights without a loss; but if they could supply 6,000 lights with a profit, and if they could run this up to 13,000 lights, there was a possibility of making a profit of £1,000 a year.

Tenders Required for Hanley.—Tenders are invited by the 29th inst., as notified in our advertisement columns, for the electric light wiring and fittings to the Corporation buildings—namely, (1) Town Hall and Victoria Hall; (2) free library; (3) museum; (4) public baths; (5) vegetable and fish markets; (6) butchers' market; (7) electricity generating station; also for (8) electricity meters, main double-pole switches and fuses, and other stores; and for (9) electrical testing and measuring central-station instruments. Specifications, plans, and particulars may be obtained from Mr. Joseph Lobley, borough engineer, Town Hall, Hanley. A deposit of £1 will be required respecting items 1 to 7, which will be returned on receipt of *bonâ fide* tender. Separate tenders, sealed and endorsed, to be sent to the borough engineer.

City and Guilds Technical College, Finsbury.—A special course of three lectures on "Governing Arrangements of Engines," by Mr. R. G. Blaine, M.E., A.M.I.C.E., will be given on Thursday evenings, from 7.30 p.m. to 8.30 p.m., commencing Thursday, the 18th inst. The following is the syllabus of lectures: Lecture I. — January 18 — Elementary Principles; Centrifugal Force; Rules; Simple Conical Pendulum Governors; Effect of "Loading" a Governor; Fluctuation of Speed; Isochronism; Parabolic Governors; Numerical Examples. Lecture II. — January 25—Hartnell's and other Spring Governors; Automatic Regulation of Expansion by Corliss, Pröell, and other "Trip" Gears; Supplementary Governors and Governor Attachments; Defects of Various Governing Arrangements; the Testing of Engine Governors. Lecture III.—February 1—The Governing of Marine Engines; Balanced and Spring Governors: Pneumatic Governors; "Fluid-Friction" Governers; Governors for Gas and Petroleum Engines; Electric Governors; Conclusions.

Bury.—The Electric Lighting Committee of the Town Council have reported that at a meeting on the 20th ult. it was resolved that the Mayor be the chairman of this committee for the ensuing municipal year. Mr. Cartwright again submitted the schemes and tenders for the lighting of the borough with electric light, and read a report, which incorporated another report drawn by Mr. Wynne, the electrical engineer. Mr. Cartwright informed the committee that Mr. Wynne had convinced him that the continuous-current system was the best, and after reviewing and criticising the various schemes, advised the committee not to accept any of the schemes and tenders sent in, but to allow Mr. Wynne to prepare an entirely new scheme upon the continuous-current system. On the minutes of the Electric Lighting Committee coming up for confirmation last week, Councillor Bentley suggested that the steam needed to drive the engine be generated by waste heat from the destructors. As the destructors were to be erected in the spring, he urged that no time should be lost, and that the committee should meet at the earliest opportunity to consider the question.

Heysham.—Last week a meeting of ratepayers within that portion of the parish of Heysham called "Sandylands," and adjoining the West End of Morecambe, was held at the Cumberland View Inn, to receive the report of the recently-appointed inspectors for the lighting district recently formed under the Lighting Act. Tenders from the Morecambe Gas and Electric Light Companies for the lighting of the promenade and highway from the Battery Inn to Cross Cop were read and considered, after which it was resolved to adopt a scheme of electric lighting, the Morecambe Electric Light Company undertaking to fix and supply 25 16-c p. incandescent lamps during eight months of the year, and in June, July, August, and September substitute for the proposed 10 lights on the promenade an equal number of 500-c.p. arc lamps. For this their charge would be £49 per year; but as this would not cover the cost of installation, they stipulated that the contract be for three years, and that they have the right to supply for private lighting and motive-power purposes within the lighting area. The total cost for gas lighting, including interest on outlay, and providing for lighting, extinguishing, and repairing lamps, was estimated at £95 per year. It is expected that the installation will be completed in 10 weeks' time.

Electric Lighting at Cambridge.—The Town Council last week received a report from the Paving, Drainage, and Lighting Committee. The committee reported that they had considered the report of the Electric Lighting Committee with reference to the application by the Cambridge Electric Supply Company, Limited, to make certain exceptions to the delivery of a constant supply of energy, together with letters from the junior bursar of Trinity College and the secretary to the University Union Society thereon, which report and letters were referred to the committee by the Council on the 14th ult. The Paving, etc., Committee, after consideration of the objections made in the letters above referred to, and to the proposals of the Electric Lighting Committee, recommended that the company be permitted to make the following exceptions to a constant supply: On weekdays, from October 1 to June 25 inclusive, from 2 a.m. to 6 a.m.; from June 26 to September 30 inclusive, from 2 a.m. to 5 p.m.; on Sundays, from April 1 to September 30 inclusive, from 1 a.m. to 5 p.m.; from October 1 to March 31 inclusive, from 1 a.m. to 2.30 p.m. The committee further recommended that it be made a condition with the company that on a demand by any consumer for not less than 20 lights of 16 c.p. for any particular occasion, the supply should be continued until sunrise. After some discussion, the report was adopted, slightly amended.

Bournemouth.—Some discussion took place at a meeting of the Town Council last week on a motion brought forward by Councillor Haydon to rescind the resolution of the Council passed on December 22, 1892, authorising the construction of subways "for the purpose of enabling the proposed fountains to be illuminated with the electric light." Councillor Haydon maintained that the expenditure would not be justified, either on the grounds of necessity or attraction. Councillor Cutler seconded, and said it would have been a different matter if the fountains were to be placed in

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the winter garden, where people paid for admission. In reply to Councillor Mattocks, the surveyor said the cost of the fountains and the subways was estimated at £900. The fountains were to cost £250 each apart from the electric light work. Councillor Roker said they had already raised a loan of £500 for the fountains, and they could not very well abandon that part of the work, but nobody wished to raise the rates unnecessarily, and he should vote against the additional expenditure of £400 for illuminations. Councillor Hoare thought it much better to do the work now, and he would like to move as an amendment that the chambers for the electric light be put in. Councillor Davis said he would be pleased to second the amendment. The Mayor said he could not receive it as an amendment, as it was a direct negative. After further discussion, the motion was carried.

Lighting of Swansea.—The question of electric lighting, to which we have referred in recent issues, is engaging the attention of the members of the Corporation. The Electric Lighting Committee is composed of some of the most practical men on the Council. The committee is as follows: Aldermen H. A. Chapman (ex-mayor), Richard Martin, M. Tutton, W. Richards, A. Mason, Councillors R. S. Lindley, Thomas Freeman, and G. Morgan. Several meetings have been held: interviews with four different experts have taken place, and every effort is being made to obtain the best and most reliable information. Several schemes have been suggested, but not one has been definitely fixed upon as yet. The attempt on the part of a private company to obtain a provisional order, as against the order granted the Corporation in 1889, has been overcome by the action of the Electric Lighting Committee. Of the different schemes submitted, two include the destruction of the town refuse by destructors. The committee are considering the details of the schemes, but are determined not to adopt one without the advice of an expert. For that purpose they have engaged Mr. Manville, of Messrs. Waller, Manville, and Kincaid, whom they will pay 50 guineas to prepare a report as to the best way of lighting that town by electricity, and of utilising the refuse. It is estimated that the scheme will cost £30,000, and that a sufficient profit will be realised to pay for the lighting of the whole of the streets.

Confirmation of Halifax Tenders. — After considerable difficulty a suitable site for the electricity works has at last been found, and the purchase was confirmed on Wednesday last by a special meeting of the Council. The site, which is about 400 yards from the one originally decided on in Cripplegate, is an excellent one, and has an area of nearly 5,000 yards. Coal can be shot direct into the boiler-house from the railway, and condensing water is plentiful. Two sub stations, each of 100-kilowatt capacity, are now under construction, from which a three-wire network will supply the centre of the town, the outer district being at first served by separate transformers. The Council also confirmed the following contracts, which were given out by the Electric Lighting Committee some weeks ago: Boilers and mechanical stokers: Yates and Thom, Limited, £1,688; Green's economiser: Yates and Thom, Limited, £489; horizontal engines: Pollit and Wigzell, Limited, £1,860; condensers: Pollit and Wigzell, Limited, £225; alternators and exciters: Electric Construction Company, Limited, £2,055 (amended tender); switchboard: John Fowler and Co., Limited, £460; transformers and fittings: C. A. Parsons and Co, £844. 6s.; cables, pipes, etc.: Siemens Bros. and Co., Limited, £7,450; trench digging: Watkins and Wilson, Halifax, under footpath, 9½d. per yard, road 1s. 7d.; two horizontal engines for exciters: Robey and Co., Limited, £317; sub-stations: H. Jenkinson and Co., Halifax, £79. 15s. 8d.

Whitehaven.—The Town and Harbour Trust last week confirmed the minutes of the Electric Light Committee. The minutes stated that the surveyor reported that at present there were 550 16-c.p. lamps supplied with current, and applications had been received for an additional 480 lamps, exclusive of the street and harbour lamps. Mr. Musgrave mentioned that he understood that so far the committee had sufficient power to supply all applications that had been made, and that the committee were making every effort to meet those applications. Of course they understood that in the first year of such an experiment there would be some little difficulties to overcome; but, so far as he could understand, the electric lighting might be considered a success. That being so, he would like to know whether provision had been made for further extension of the private wires throughout the district. The Chairman said, in reply, that the generating machinery was sufficient for the applications at present, but he thought it would be patent to everybody that before next year it would be necessary to put down more plant. The engines were now running almost to their utmost capacity, and they hoped that the accounts on March 21 next would be so satisfactory as to leave no doubt whatever in the mind of any one trustee as to the expediency of duplicating or at all events considerably augmenting their plant. It was not the intention of the Electric Lighting Committee to bring this matter before the Board until they were in a position to give some result of the present year's working.

Lighting at Chester.—A monthly meeting of the Chester Town Council was held on Wednesday, the principal business being a motion proposed by Alderman H. T. Brown that the memorial of the dean and chapter against the utilisation of the Hop-pole Paddock as the site of the proposed electric lighting station be further considered and a reply sent to it. He pointed out that, although the memorial had been presented two months ago, no reply had been sent to the dean and chapter, and in this respect the Council had shown scant courtesy. The memorial, he said, was divided into two parts. The first was a protest against the Paddock being used as proposed, and the second was what almost amounted to an offer from the dean and chapter to concur with the Corporation in securing the Paddock as an open space for the citizens. The Council resolved, by 17 votes to 9, that the Paddock should be the site of the generating station, but he pointed out that the second part of the memorial had not been taken into consideration. He did not wish to reopen the question, and he merely asked that the Council should sanction a reply being sent to the dean and chapter. The Deputy-Mayor admitted that the Council had come to their decision rather hastily. If they had seen the plans he did not think they would have approved of erecting buildings of that character so near the walls, not to speak of the cathedral. Mr. G. A. Dickson seconded the resolution. Mr. W. H. Churton regretted that there should have been an oversight in replying to the memorial of the dean and chapter, and moved that the resolution of the Council be sent as a reply, with an expression of regret that they could not accede to the wish of the memorialists. He assured the Council that the Electric Lighting Committee were not going on with the matter too hastily. Before proceeding further, they were to have an assurance from an expert electrical engineer that there would be no likelihood of damage to the walls or cathedral resulting from the erection of the electric station in the Paddock. They would have no ugly buildings erected which would be a disfigurement to the surroundings, and they wanted the engineer to be responsible for any damage to the walls, the cathedral, or the adjoining property. Mr. W. C. Deeley seconded Mr. Churton's resolution, which was carried.

Battersea and Electric Lighting.—On Wednesday evening, Mr. W. Willis, L.C.C., brought forward two motions, of which he had given notice, at a meeting of the Vestry of the parish of St. Mary, Battersea, the first being to revive the question of lighting the parish by electricity; and the second that a new committee, consisting of five members from each ward, be appointed to enquire fully into the matter, and to report to the Vestry. Mr. Willis stated that on September 23, 1891, he had moved a resolution that it was expedient to seriously consider the lighting of the parish electrically, and that a special committee should enquire into the cost and practicability. The Vestry as a whole was then apparently opposed to the electric light, and the committee having been agreed upon, appointed as its members those who were avowedly opposed to electric lighting. At that time a company, the Putney and Hammersmith Electric Lighting Company, had applied for powers, and the committee reported that they considered the company had precedence of the Vestry, and that it should be allowed to go ahead. This company had abandoned its powers some time ago, and Mr. Willis accordingly proposed the motions which stood in his name, and these were seconded by Mr. Morels. Mr. Taylor proposed as an amendment that the subject should be postponed until a new vestry had been elected in November next, but practically unanimity prevailed in favour of Mr. Willis's proposals. Mr. Cosligan approved of the appointment of a committee, and said there could be no sensible objection to it, as it would simply search for information. The electric light was bound to come in the course of a few years. He, however, thought that a committee composed exclusively of Battersea vestrymen would be of little use, and that they should have an expert as a guide. Mr. Howarth Barnes, who, when Mr. Willis moved the appointment of the original committee, had suggested that its appointment be postponed for two years, now supported Mr. Willis, stating that he thought that immense progress had been made in electric lighting. Mr. Hart was of opinion that if any profit was to be made out of electric lighting, the Vestry should have it, and he adduced statistics showing the success which had been met with in St. Pancras, which was the only London parish which had gone in for electric lighting, and he also pointed to the good results which had been obtained by municipalities in Bristol, Dublin, Brighton, Huddersfield, and other towns. The motions were agreed to, and a committee was appointed consisting of Messrs. Willis, Shutter, Holloway, Clifford Smith, McGill, Marsen, Nelson, Bootle, May, Davies, Hart, Morels, J. H. Hunt, Winchester, Parr, Derby, Scholfield, Mansel, Munslow, and Barnes.

Lighting at Wolverhampton.—Mr. Codrington, one of the Local Government Board inspectors, held an enquiry last week relative to an application by the Corporation for a loan of £30,000 for carrying out an electric lighting scheme in the borough. There was no opposition. The town clerk appeared to support the application, and there were also present the Mayor (Alderman C. T. Mander), Mr. A. P. Brevitt (architect), Mr. R. E. W. Berrington (borough engineer), and Mr. F. H. Lewis (electrical engineer to the Corporation). The Town Clerk said the provisional order under which the Corporation sought to supply the electric light for public and private purposes was granted on August 4, 1890. So far as the electric lighting extension was concerned, the Board's consent had already been obtained to a loan under the Electric Lighting Act for the purchase of land adjoining other land belonging to the Corporation in Commercial-road, and now used as a wharf. A generating station was about to be erected according to plans which had been prepared by the architect (Mr. Brevitt), at an estimated cost of £4,985, according to an accepted tender. The electrical engineer to the Corporation (Mr. Lewis) had had considerable experience, and the Corporation had every confidence in the scheme he had submitted. The central station would, he said, be at the Town Hall, with branch stations at the Art Gallery and the Free Library. It was proposed to light the streets by means of arc lamps. There would be 42 lamps, and 20 of them would be extinguished at 12 o'clock at night, and the others would be left till a later hour. The trunk mains, which were high-pressure feeding and low-pressure distributing, would be so insulated as to comply with the requirements of the Board of Trade, and there would be certain pre-

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cautions which would prevent any danger. The whole scheme had been submitted to the Board of Trade, and although he had received a reply which was virtually a consent to the scheme, he had not yet had their formal consent, the Board stating that they would be unable to send their formal approval by the date named in his letter. The estimated cost of the scheme was £30,000, of which £17,442. 14s. 2d. was for plant, and £1,320 for arc lamps, and £2,243 would be left for contingencies. With regard to the question of the repayment of the loan, he had written to the Local Government Board asking whether they had any powers to suspend the operation of the sinking fund with respect to this undertaking for a few years, in order to enable the Corporation to turn round during the time between the commencement of the work and the completion of it. He was to ask that the longest possible period which could be should be allowed the Corporation, who were one of the first boroughs in the district to carry into effect the electric lighting order. It was very necessary, in the interests of the ratepayers, having regard to the high rates, that they should have a little latitude in the period allowed for repayment. It was not to be supposed that the Corporation would make instant profit. The first year or two would be very trying. The electrical engineer estimated the dead annual expenditure at £3,307, and to cover this a minimum annual consumption would be required of 193,600 units at 6d. per unit, which was equivalent to the consumption of 5,308 c.p. lamps and 50 arc lamps. Evidence having been given by Mr. Lewis (the electrical engineer), Mr. A. P. Brevitt (architect), and Mr. Howell (borough accountant), in reply to a question, the Inspector said he thought expenditure in the laying out of fittings might be regarded as capital expenditure, and that a loan might be applied for. The proceedings then terminated.

Monmouth.—The Town Council on two occasions last week discussed the questions of sewerage and electric lighting. At the second meeting the Mayor remarked that there was so much to be duplicated in the drainage and electric lighting schemes that it would be well for the members of the Corporation to have a clearer view of the matter than was conveyed in the figures afforded at the previous meeting. He had since gone carefully through them, cut out the duplicates, and divided them into four headings as follows: Sewerage, purification works, lighting, and what he called the junction works—that was, where the schemes touched each other. Under the head of sewerage, the amount for the sewers themselves was £5,425 (these were the figures of the amended schemes now before the Local Government Board), contingencies, £545; compensation, £35; engineering fees, £390; and legal, £70; making a total of £6,465. Under the head of purification works were—tanks and filters, £980; receiving tanks and pumps, £800; rising main, £100; for that proportion of land, £400; ploughing land, mixers, and roads on works, £150; 10 per cent. contingencies, £397; compensation, £15; fees, £190; legal, £30; total £3,062. The items for lighting were—generating plant, with two engines of 70 h.p., one boiler, and three turbines of 70 h p., £4,884; trenching, £250; total, £5,134. He did not approve of some of the items in the junction works; they seemed to him to be unnecessarily expensive. However, the figures were for deepening 700ft. of existing channel, £233; head-race, £1,161; culvert under the railway, £388; tail-race, £317; weir, £68; fish grating, £101; accommodation works over the canal, required by the solicitors to the Duke of Beaufort, £250; land, £162; turbine well, £389; buildings and machinery foundations, £1,000; contingencies, £200; total, £4,269. Colonel Walwyn asked if any agreement had been entered into with the Brush Company. The Mayor observed that they had accepted their tender. Alderman Vizard said that no final agreement with them had been made. The Mayor replied that the selection was provisional. The total sum required to be spent over the two schemes, as they stood at present, was £18,930, which was an advance of £930 upon the figures placed before them before. The difference was to be accounted for in this way. The present tender of the Brush Company was £4,884, and it had been increased to that amount from £4,246, the amount of the accepted tender of November 16, 1893, on account of the fresh demands which had been made upon them. There was a difference of £638. The increase had arisen partly at the instance of the Corporation themselves in view of a reduction in the annual expenditure. There was further £101 for fish gratings asked for, at the head and tail of the race, by the river surveyors; £250 for accommodation works asked for by the agents of the Duke of Beaufort; and £250 for trenching, which originally appeared in Mr. Lailey's scheme, but which had now been transferred to the lighting scheme because it had nothing whatever to do with the sewerage. The Mayor explained the arrangement by which two engines of 35 h.p. each had been adopted instead of one of 60 h.p., and three turbines of 23½ h.p. each instead of two of 30 h.p. The possible reduction in the annual cost when only a small power was required was obvious. Alderman Vizard asked who was responsible to them for the figures relating to electric lighting. The Mayor replied the Brush Company, who gave them the figures. It was eventually decided that a competent engineer be employed to go into the matter, take his own measurements, and give them his own opinion on the figures relating to the project for electric lighting. The Mayor said that under these circumstances the town clerk had better write to the Institute of Civil Engineers at once, and get them to nominate some hydraulic engineer with whom they might get into correspondence as to charges, etc. The town clerk was instructed accordingly.

Lighting of Guildford.—As stated in our last issue, the Town Council have given consent to the application of the Holloway Electricity Company to the Board of Trade for a provisional order, on the understanding that the undertaking may be acquired by the town in 10 years, if such should be deemed advisable. In this connection, the letter read at a meeting of the Council last week from Mr. H. A. Folkard, the secretary of the company, is worthy of note. The letter stated: "It will be within your recollection that in 1882 Parliament passed an Electric Lighting Act which contains a clause enabling local authorities to buy up undertakings after 21 years upon the terms of Section 2 of the Act. This Act so much failed in its object that in 1888 Parliament passed another Electric Lighting Act, which increased the period for compulsory purchase from 21 to 42 years from the date of the order. The conditions of purchase as unanimously agreed to by your Council, and forwarded to this company,, are based on Section 2 of the Act of 1888, with power to purchase the undertaking at the expiration, not of 42 years, nor even of 21 years (which period was considered too short by the Legislature), but after a lapse of 10 years only. Obviously, this condition does not carry out the spirit of the Act, but is, on the contrary, in direct antagonism to it. As this provision, if insisted upon, will entirely check the commencement of lighting in your borough by private enterprise, I am further directed to ask you to lay this letter before the authority at its next meeting, with a respectful request that the members will reconsider our application of the 6th ult., and give such consent as will enable this beneficial undertaking in the town to be carried out." The Town Clerk, after having read the letter, stated that he believed January 15 was the last day for sending in objections to the provisional order, and he thought a committee should consider in some way the form to be agreed on. Alderman Mason moved that the question be referred back to the committee for reconsideration. Councillor Salsbury said he should have no objection to second that, but he did not think it would meet the point unless the committee had power to act, because the Council would not meet for another fortnight, and the time would have elapsed before that. The Town Clerk thought the committee should have power to send in objections, but, of course, the committee could not take power to alter the period. January 15 was not the last day for deciding one way or the other whether they would extend the 10 years or not. Councillor Emery said that 10 years seemed rather a short period. It would be rather unfair to come in and buy up the works at old metal price, and not give the company some recompense for their outlay. Councillor Wrist said he supposed the Council saw no objection to the provisional order; they had all agreed to it. The Mayor explained that, supposing the provisional order were to pass as it was now, there was no term at all. In the general Act of Parliament there was a term of 42 years, but the Council asked that there should be a condition for purchase after the end of 10 years, and every five years subsequently. That had not been inserted, and if they wanted it inserted, or any condition fixing the time at less than 42 years, they must object to it as it stood, because it did not contain anything of that sort. Councillor Bullen presumed it was not competent at that meeting to move an alteration of the period suggested. The Mayor replied that it was not on the agenda. But it did not seem to be essential that they should do it then; there would be plenty of time afterwards, if they chose to lodge any objection. If they were willing to accept the 42 years, they need not trouble to lodge any objection. Councillor Bullen said he must admit that 10 years did seem a short period for persons to come and get all their appliances, etc., and, before the thing had got into good working order, to stand the chance of losing it. A motion was eventually passed referring the subject back to the General Purposes Committee, with power to take such steps as they might think necessary.

Lighting and Traction at Blackpool.—The subject of electric lighting extensions was warmly discussed by the Town Council last week. Mr. Councillor Bickerstaffe referred to the minute desiring Mr. R. Hammond to report and advise the Corporation upon any extensions required in connection with the electric light installation. Before anything was done, he said, he should like to have some idea of what money had been already expended on the station, and some information as to whether the results were likely to pay any reasonable interest for this extra outlay. Pending such explanation he should move that this minute be referred back. Mr. Alderman Parkinson seconded, remarking that they had an electrical engineer who should be capable of advising the Electric Lighting Committee, and he did not see why they should not place the responsibility upon him, and not put another man over his head. Mr. Councillor Ward thought that if the committee looked upon their electrical engineer as incompetent for developing any further scheme, the Council should be acquainted of the fact. Mr. Councillor Heap said that did the members of the Council know exactly the position the committee had taken, that amendment would not be persisted with. The committee had been brought face to face with a greater demand than the present machinery could cope with, and they were simply looking forward to the time when they would have to increase their plant in order to meet the requirements of the town. He could hardly see that the members of the Council were in the entire ignorance they professed on this matter. The committee knew exactly what the station was costing, and what the electric light was costing them. Mr. Councillor Heap, in reply to a question as to why all the information was kept by the committee, said that there was no secresy; every consumer of current knew what he was paying. The committee could see that some extension was requisite, and they were merely proposing to obtain advice from the engineer who had made their installation for them. Their engineer might be as capable of reporting to them as anyone, and might perhaps hold the opinion himself, but they preferred to go to the engineer who had conducted the installation. Mr. Councillor Sergenson said that they had understood for some time that this would be necessary. The Mayor observed

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that, if he remembered rightly, Councillor Pearson said that such a step would be necessary. He felt very pleased that there was such a resolution on the books; it showed that Blackpool was progressing. Mr. Councillor Bickerstaffe remarked that they were first asked to give them £26,000, and now they would be asked for another £20,000. Mr. Councillor Pearson said that there seemed to be some misunderstanding as to what the duties of their engineer really were. It was perfectly understood when the appointment of a resident engineer was recommended that he should take care of the plant; it was not for the engineer to tamper or tinker with anyone's scheme, a system perhaps which had taken a specialist years to perfect. They did not know what this system would bear in the way of extension, and while the resident engineer might undertake a small extension, it would be better to consult Mr. Hammond as to what was the best to be done. The amount of money which they originally obtained from the Corporation was £26,000, and the likelihood was that before many weeks were over they would have to ask the Finance Committee to negotiate borrowing powers for another £20,000. The consumption of the current was increasing so rapidly that they would have to make an extension which would cause an expenditure of the sum mentioned. This did not startle him, for he could always see from the first initiation that Blackpool would prove an exceptional town, and that the light would be used with avidity. Referring to a promise from the Tower Company, he said that he had been officially notified by the chairman of the Tower Company that if the Corporation could supply them with the light they would take it from the borough; if they could not supply it, the company would no doubt put down their own plant. The committee had estimated the amount of current which they anticipated would be demanded next season, and they found that they would have a demand for nearly double the current which now formed their output. They could tell to a minute fraction what the light was costing them to produce, and they had not placed the figure at the lowest ebb. Then they had to consider that the more consumers they got the more profit they would make, and at less price would they be enabled to supply the current. In his opinion the electric lighting department was going to be a good and profitable concern to the Corporation. He did not know any reason why it should now be challenged, and he could promise them that every matter would be placed before the Council before any further expense was incurred. It was to this end that the committee asked the Council to authorise them to receive a report in a proper manner from the specialist. The amendment was lost, and the minute adopted. With regard to the electric tramcars, Mr. Alderman Buckley asked what was the fee of Mr. M. Holroyd Smith, whom the Electric Lighting Committee proposed asking to inspect the tramway line and plant, besides another inspection by Mr. Thomas Parker. Mr. Councillor Pearson said Mr. Smith's fee was £10. 10s., with out-of-pocket expenses.

The Lighting Question at Newport.—Colonel J. Ord Hasted, R.E., Local Government Board inspector, held an enquiry last week into the application of the Newport Corporation for a loan of £28,000 for electric lighting. There were present at the enquiry the mayor (Councillor F. Phillips), Alderman Moses (chairman of the Electric Lighting Committee), Mr. R. Hammond (electrical engineer consulted by the Corporation), and the borough surveyor (Mr. J. H. Haines). The Town Clerk stated that in the session 1893 three companies applied for provisional orders to supply Newport with electricity, each of which the Newport Corporation opposed. The Corporation was informed by the Board of Trade that the applications would be refused on the understanding that the Corporation would themselves apply for a provisional order in the following session. Accordingly the Corporation sought for and obtained a provisional order in the session 1891. The representatives of the Corporation visited several towns in the kingdom for the purpose of ascertaining which system would be the best to adopt. Eventually, they decided in favour of the high-tension alternating-current system, and they retained the services of Mr. R. Hammond as consulting electrical engineer. The estimate of expenditure put in by Mr. Hammond was £20,000. That was the original estimate sent to the Local Government Board. The Corporation had since then advertised and obtained tenders. As a result of these tenders, it was expected that the original estimate would be exceeded, not by a large sum, but by some amount. As to the prospects of the proposed installation, the Corporation themselves were very large consumers of gas at the various public buildings and institutions of the borough, and, in addition, they had to pay for the gas supply for 800 public lamps in the borough. It was not proposed at the outset to light more than 40 arc lamps in the main streets of the borough, but the whole of the supply they intended to give they hoped would be taken up by the private consumers. The lighting station would be erected on land belonging to the Corporation. Mr. Hammond, who described the scheme, stated that under the provisional order granted to the Newport Corporation the compulsory area included High-street, Commercial-street, Commercial-road, Dock-street, and Baneswell-road, about 5,000 yards in extent. The Corporation, however, desired to place the light at the disposal of as large a number of ratepayers as possible, and had decided to at once lay down mains which would include a total area of 12,300 yards for the purposes of private supply. For incandescent lighting 4,300 yards of mains would be laid, and the Corporation proposed to lay down 4,850 yards of mains for arc lighting. With regard to the means of generating electricity, the site which had been adopted was admirably suited for electrical works. It was close to the Monmouthshire Canal, from which water could be obtained for condensing purposes at a nominal rental of £25 per annum, and there was also a railway running near, by which a coal supply was easily obtainable. With regard to the capacity of the station, the scheme involved the provision of plant for 7,500 lights, all burning at once, and also arc plant capable of running 150 arc lights. This plant would be divided into sections, so that by means of keeping one plant in reserve the chance of breakdown would be avoided and the necessity of storage obviated. The reason for the difference in the original estimate and the present estimate was that the specification had been strengthened. With a view to economical working during the hours of very early morning and until sunset of each day a small engine would be used, so that the cost of running the large engines of 150 h.p. would be avoided. In answer to the inspector, Mr. Hammond said that the scheme had not yet received the approval of the Board of Trade, as they were considering replies to certain questions put by them to the Corporation. Alderman Moses said the Corporation were anxious to proceed with the work as quickly as possible. Mr. Hammond having put in a list of tenders received, amounting to 60, the enquiry then closed. The Town Council, on Tuesday, discussed at some length and warmth the report of the Electric Lighting Committee, who recommended that the all-round tender of Messrs. John Fowler and Co. (Leeds), Limited, at the sum of £23,384 for the whole installation, less the amount of £3,756, the tendered price for cables, should be accepted. The question of accepting a separate tender for the cables having been considered, it was recommended that the tender of Messrs. Siemens and Co. for the cables at the sum of £2,896, subject to the cables being made in England, be accepted. It appeared that the next lowest tender was that of Messrs. Crompton at £20,780. The recommendation of the Electric Lighting Committee deciding to accept the tender of Messrs. Fowler and Co. was ultimately referred back to the committee.

Electric Lighting at Wigan.—When the confirmation of the minutes of the Gas and Electric Lighting Committee of the Town Council was moved last week by Mr. C. B. Holmes, Mr. Laycock stated that he had read the circular that had been issued by the town clerk in regard to electric lighting, and an abstract of which is given below. Mr. Laycock said that some people did not exactly understand it. He took it that at a cost of 2s. 4½d. they got the same illuminating power from gas that they would have to pay 5s. for electricity. Mr. Holmes said he believed that was considered a fair average. Mr. Laycock suggested that before anything was done in the matter a meeting of tradesmen should be called, and all the information respecting the electric light be placed before them. Alderman Phillips agreed with the suggestion of Mr. Laycock, and thought that, if practicable, the electric light should be carried out. He had been informed that the cost of gas was 2s. as against 3s. for electricity. Mr. Holmes, in reply to Mr. McQuaid, said they felt that when the electric light was introduced it would for years be a loss to the town, but it was the general desire that it should be provided by the Corporation. The committee, however, did not want to rush into any extravagant expenditure. He concurred with the suggestion of Mr. Laycock, and thought the meeting might be held in the old Council-chamber. The minutes were confirmed. The circular referred to reminded the ratepayers that in 1890 the Corporation obtained a provisional order, but as there did not then appear to be any general desire on the part of the public to adopt this system of lighting in preference to gas, no electrical works were laid down. The Corporation, however, thought it right to state that they were prepared to undertake to supply electric current in certain streets, if such be the wish of the ratepayers. The town clerk therefore asked the ratepayers whether they would agree to take electric current for lighting purposes, if provided by the Corporation, for a fixed period of three years at 6d. per Board of Trade unit. Continuing, the town clerk says: "I may say that the Board of Trade have made the equivalent of electric current to be 10 units to 1,000 cubic feet of gas. A unit will supply about 30 glow or incandescent lamps of 8 c.p. each, of suitable efficiency for one hour; therefore, as an ordinary efficient flat-flame gas-burner, consuming at the rate of five cubic feet per hour, will be equal to 11 sperm candles power, 10 'units' of electric current will, when supplied to 300 8-c.p. incandescent lamps, give an illumination equal to 2,400 sperm candles over a period of one hour; 1,000ft. of gas consumed by the ordinary efficient flat-flame burners will give an illuminating power equal to 2,800 sperm candles during the same period; the cost of the current being 10 units at 6d. = 5s., the cost of the gas being 1,000 cubic feet at 3s., less 10 per cent. discount = 2s. 8½d.; if, however, the consumer of gas is entitled to 23 per cent. discount, the relative cost would be—electric current, 5s. net; gas, 2s. 4½d. net." With reference to this circular, Mr. G. Stephen Corlett has written to a Wigan paper as follows: "The circular expresses in a remarkably lucid manner the method of arriving at the relative cost of gas and electricity, but I do not think the final conclusions are quite correct—that is to say, the electricity bill will compare more favourably with that of gas than appears from the circular. It is stated that one unit (1,000 watts for an hour) of electricity will supply 30 lamps of 8 c.p. for an hour, which means that the lamps will be working at an efficiency of $\frac{1000}{240} = 4{\cdot}16$ watts per candle-power—a very low standard to take. A few weeks ago I had occasion to test an installation of 950 Edison-Swan 16 c.p. lamps, fitted during the summer by my company, and found the efficiency to work out exactly to 3·75 watts per candle-power. This result can generally be obtained from Edison-Swan lamps, and is about 10 per cent. better than the figures given by the Corporation. But the master patents held by the Edison-Swan Company have recently lapsed, and much more efficient lamps are now available, one type of which, at an efficiency of 2·6 or 2·7 watts per candle-power, has a life of 500 hours, and only costs 1s. 9d. per lamp. It seems to me only fair that, when

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considering relative cost of gas and electricity, the question of lamp renewal should be taken into account. I do not consider that any fair comparison of light given can be obtained by considering the costs of two fixed quantities of gas and electricity; surely the light from the 1,000 cubic feet of gas will vary according to the state of the burners, and that given by the 10 units of electricity according to the efficiency of the lamps. A lamp of 16 c.p. burning for 1,000 hours at 2·7 watts will take 43·2 units, and will cost for that time, 43·2 units at 6d., £1. 1s. 7d.; two new lamps at 1s. 9d., 3s. 6d.; total £1. 5s. 1d. Taking for gas the figures given by the town clerk—viz., 14 c.p. per hour for 5 cubic feet of gas (probably about the best results possible), it appears $16 \times 1,000 \times 5 \div 14 = 5,715$ cubic feet of gas will be required to give 16 c.p. for 1,000 hours. It should be noted that the price of gas will shortly be raised to 3s. 3d. per 1,000, and I think our calculations should be based on the figure less 10 per cent. If a gas consumer be entitled to 20 per cent., it is only fair to assume that he would have a proportionate reduction on his electric light, as is the custom in most large towns; 5,715 cubic feet at 3s. 3d., less 10 per cent., equals 16s. 7d. So that for a 16-c.p. lamp for 1,000 hours the relative cost would be—gas 16s. 7d., electricity £1. 5s. 1d., or about 33½ per cent. in favour of gas."

The Birmingham and Midland Institute Conversazione.—This conversazione, to which reference was made in our last issue, commenced on Tuesday, and will be concluded to-night (Friday). There is an exhibition of machinery, models, and electrical appliances by the Birmingham Electric Supply Company, Limited, who are supplying the electric current for working the same from their street mains. The arrangements have been carried out by Mr. J. C. Vaudrey, the company's engineer. At two stands, which have been furnished and decorated by Messrs. Norton and Co. as drawing and dining rooms, there is an illustration of the advantages of electric lighting as an illuminant. In the drawing-room the cut glass and fittings have been supplied by Messrs F. and C. Osler. From the centre of the ceiling hangs a magnificent fuchsia-shaped five-light chandelier in cut-glass; there is a handsome electric floor lamp of three lights, and two pendants, while the sideboard contains two table lamps and a couple of crystal vases, which also reflect the electric light. The designs of these lamps are exceedingly rich and pretty, the Moorish pendants and the beautiful Venetian vases being rare examples of skilful workmanship. The floor lamp is portable, and connected to the electric supply by a flexible cord and plug. The dining-room is fitted with copper and brass by Messrs. Evered and Co. A handsome three-light copper and silver plate chandelier ornaments the centre of the apartment. Upon the overmantel are reading lamps, and overhanging the sideboard are a couple of tripod pendants. In another portion of the room the various details of the company's underground system are displayed. There is, first of all, a street service box open for inspection, with the sections of the service line laid bare. The system adopted in making the house connections is illustrated, and the meter shelf, containing a meter and a small section of casing, is exhibited to show the standard method of wiring. There are also various sections of mains shown by the Callender Bitumen Company, Limited, who are the contractors for the laying of the mains in Birmingham. Two types of meters used by the company, and lent by Messrs. Chamberlain and Hookham and Messrs. Ferranti, are exhibited on an adjoining stand—one with the interior exposed and the other in pieces. The company have between 300 and 400 such meters in use. Stand 5 is entirely devoted to illustrations of the method of using electricity as a motive power. Small motors are exhibited, driving direct the following machinery: 30in. lathe, lent by Messrs. James Archdale and Co.; jeweller's lathe and jeweller's drill, lent by Messrs. C. Churchill and Co.; buffing machine, lent by Mr. G. H. Johnstone: hair-brushing machinery, lent by Messrs. Osborne, Garrett, and Co.; Blackman ventilating fan, lent by the Blackman Ventilating Company; Sturtevant blower, lent by the General Electric Company, Limited, London; dental lathe and dental drill, lent by Messrs. Cuttries, Wallis, and Co., Limited, Leeds; and a Singer sewing machine, lent by Mr. Henry Lea, M.I.C.E. This last exhibit will be specially interesting to ladies. The electric motor is mounted upon a rocking frame, which is connected by a cord to the ordinary treadle. The treadle is not continuously worked up and down by the foot, as is commonly the case, but is simply held down by the foot as long as the machine is required to work. A single movement of the foot thus successively performs the three operations—it takes off the brake, turns on the electric current, and tightens the driving belt. When pressure of the foot is removed, a coiled spring slackens the driving belt, cuts off the electric current, and applies the brake. In either case the three operations are performed apparently instantaneously by the slight movement of the foot. Motors for machines have been lent also by Messrs. Crompton and Co., Limited, and the Electric Construction Company, Wolverhampton. To enhance the value of these exhibits the speed and approximate power of each motor is indicated on the stands. Another part of the room is fitted up as a kitchen wherein heating and cooking by electricity are practically demonstrated. The apparatus has been lent by Messrs. Crompton and Co., Limited, of Chelmsford and London, and the cooking is carried out under the superintendence of Mrs. Seaton, London. Various other appliances, lent by the General Electric Company, are shown at work. The Edison-Swan Company have lent a collection of incandescent lamps from 2,000 c.p. to 8 c.p. A most interesting side show is made up of a historical collection of incandescent lamps belonging to Mr. J. C. Vaudry, M.I.C.E., the Birmingham Electrical Supply Company's engineer, under whose direction the whole of the arrangements in this department have been carried out. Four types of arc lamps—the Brockie-Pell, Crompton-Pochin, Luna, and the Mathieson—used on the circuits in the town are shown mounted and with the works exposed, and several examples of standard electric light fittings complete the exhibits in the electricity department. An attraction on Tuesday was the telephonic transmission of musical and theatrical performances from the Metropolis and some of the principal towns in the country, in connection with the National Telephone Company's system. The rooms in which the receivers were placed were crowded throughout the evening, and the visitors thoroughly enjoyed the novel experience of listening to operatic and pantomime work in distant towns. The pantomimes at Liverpool and Manchester, nearly 100 miles off, were clearly heard; and the institute was also connected with the theatres at Bristol, 99 miles distant; Gloucester, 60 miles; Cheltenham, 50 miles; Leeds, 136½ miles, and Newcastle-on-Tyne, 235½ miles. The distance did not seem to matter, for one performance appeared to be heard as well as another. The telephone was also connected with the house of Dr. Taylor, Stafford, where a concert of vocal and instrumental music was heard splendidly.

Electric Lighting of Brighton.—A special report of the Lighting Committee, presented at a meeting of the Town Council last week, recommended the purchase of the goodwill of the Brighton and Hove Electric Light Company, Limited; that application be made to the Local Government Board for sanction to borrow further moneys for electric lighting purposes; that additional mains be laid and additional plant provided; and that the Council, by special resolution, direct an extension of the present area of supply under the Brighton Electric Lighting Order, 1883. The report having been received, Alderman Moon moved the first resolution—namely, "That the Council agree to purchase the goodwill and business of the Brighton and Hove Electric Light Company for the sum of £5,000, subject to the terms set out in the draft agreement, and that the town clerk be authorised to fix the common seal of the borough to an engrossment of such agreement." Mr. Moon thought it would be necessary for him to go over some of the old ground. It would be recollected that some two years ago the Lighting Committee entered into negotiations with the Hammond Company for the purpose of taking over their business and undertaking. These were the instructions of the Council in April, 1891, and accordingly the Lighting Committee appointed a sub-committee to negotiate with Messrs. Hammond for the purchase of the company's business. Messrs. Hammond asked for £17,500, and it was only after a very lengthy discussion and correspondence that eventually the sub-committee got the price asked reduced to £7,000. With that amount they came to the Council in November, 1891, and advised the Council to take over the Brighton and Hove Electric Light Company's undertaking at that price. He regretted to say that at that time the Council could not see their way clear to adopting the suggestion of the Lighting Committee. The committee were perfectly unanimous that it was the best thing to do, but the Council rejected the proposal. Since then they had had to oppose the company before the Board of Trade and in Parliament on their applications for provisional orders. They had also had to compete with them in their business. But to this time they had had no further practical communications with the company on any basis of purchase until, as would be seen from the report, they had a communication from Mr. Sneath, the receiver appointed by the Court on behalf of the debenture-holders, asking them if they would be inclined to take over the undertaking. Mr. Sneath then offered that they should take it over for £7,000, which was the old price, and the committee did not feel disposed to recommend the Council to give that amount at present. They accordingly suggested £5,000, and he had now very great confidence in submitting that to the Council. He found, on referring to the company's statement, that in September, 1891, at the time when the committee were proposing to take over the business for £7,000, the company had 8,168 lamps, and that the consumption on these was 67,000 units. That was the official statement, and he supposed it was accurate. Now, in September, 1893, he found that that had increased to 9,665 lamps, with a consumption of 154,000 units. Therefore the committee were now proposing to give them £5,000 for what approximated to the difference between these figures. He might say, however, that part of these lamps were in Hove, and they did not propose to take that part over. £5,000 would not be a large sum to give the company for their undertaking, and the report showed that they would be able to make a profit of something like £585 a year on the company's lamps, and that in the short time of 10 or 11 years the whole amount would be wiped off. He had all the more reason for recommending this to the Council because of the position that they themselves held. They would remember that the Corporation commenced their undertaking in 1891, and that in running the light from September to December, 1891, they made a deficit of £283. 10s. 6d. That was for three months. Then during the year 1892, after paying all expenses—all capital charges, interest charges, maintenance, and everything that could be properly charged to the undertaking—they made a profit, entirely unanticipated by any member of the Council or of the committee, of £12. 5s. 3d. At that time they made up their minds that they would reduce the price to the consumers, and the committee recommended that the price should be lowered from 7d. after the first two hours to 3½d. About 150 consumers had participated in this reduction of the price, and it resulted in reducing the average cost to every customer to 6$\frac{1}{10}$d. Notwithstanding that reduction in price, according to the estimated balance-sheet that had been given to him by Mr. Wright, it was shown that the estimated profit in 1893 would be £432. 4s. 11d. He could not say that that would be the exact amount, but he had every reason to believe that that would be within the actual figures.

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Thus, notwithstanding the large amount laid out on this undertaking, they would see that the committee had run it in a commercial and successful manner, and it could be, if necessary, appropriated to the reduction of the rates, for he had no doubt that next year would show a very much larger profit. The purchase-money they asked for was £5,000, and for additional mains and plant for supplying the company's customers £19,227. This estimate was prepared by their engineer, Mr. Wright, but, as they would see by the report, the committee had thought it wise to consult Prof. Kennedy. With one or two exceptions, the professor practically agreed with Mr. Wright's report. Mr. Wright recommended three-wire low-pressure mains for the Kemp Town district, and to feed these distributors two split feeders. Prof. Kennedy quite agreed with this method of supplying Kemp Town, but, instead of taking two feeders, he saw his way clear to supplying the district with one feeder split into three parts, one going to Bristol-road, another to Paston-place, and the third to Chichester-terrace. That, of course, would effect an economy to some extent. Then, to carry the system into the Lewes-road district, what Mr. Wright recommended involved the laying down of a very heavy and expensive feeder. Prof. Kennedy thought it would be more economical to supply this district with a small section feeder on the high-pressure system, carried underground in iron pipes; while with regard to Preston he would apply the same system that Mr. Wright had already recommended, with a loop to connect Lewes-road and Preston. These alterations were expected to result in a saving of £2,600. Thus, under this heading, they ought to deduct £2,500 or £2,600 from the £19,227. The plant and mains for supplying the Preston district were estimated to cost £4,290, and the cost of laying on new house services and purchasing additional meters was estimated at £6,483, the total estimated cost being £32,500 It was not necessary to lay out the whole of that amount simply to take over the company's customers. They were now providing not only for those customers whom they should get from the company, but they were looking forward for four or five years to come. They were in these estimates providing for 7,500 lamps, which was 6,107 more lamps than the company now had in the outlying districts. The light was now an established success, and it would be a very wise thing for the Corporation to take over the company's business, for although up to the present time the company was not doing so well as it might, yet it was very conceivable, and, indeed, very feasible, that if they liked to take away their old plant and put in better, they would be able to carry on the business successfully, and be a successful opponent to the Corporation. It would therefore be wise for the Council to get the whole business in their own hands. Councillor Ballard said he did not think the report should go forward without some criticism, not necessarily of a hostile character. They were asked, he said, to give the company £5,000 for no property whatever, only the goodwill. They were not taking the engines, or wires, or posts, or anything, but merely taking over the company's customers at the company's price; and he was afraid those prices would not be found very remunerative, especially some given lately in opposition to the Council. He believed competition a healthy thing, if there was not too much of it. Rather than the present scheme he would see the committee carrying on the company's installation, and replacing it as they found streets or districts would be better served otherwise. Alderman Reeves congratulated the committee on the decision they had arrived at, adding that he believed it to be a sound business transaction. After further discussion the report and the resolutions were unanimously adopted.

PROVISIONAL PATENTS, 1894.

JANUARY 1.

4. **Improvements in electricity meters.** Albert Ebenezer Schurr, Lyncot, Leigh-on-Sea, Essex. (Jules Cauderay, Switzerland.)
6. **Electrically-heated brands and stamps.** Gustav Binswanger, 71, Queen Victoria-street, London.
12. **Improvements in electrical indicators.** Alexander William Stewart, The Crescent, Dalmuir, Dumbarton.
46. **Improvements in electrical apparatus for controlling traffic on single lines of railway.** William Robert Sykes, jun., and Arthur George Evans, 70, Palace-chambers, Westminster.
57. **Improvements in electric motor apparatus.** William Armour Johnston, Arthur William Browne, and John Clarence Davidson, 24, Southampton-buildings, Chancery-lane, London. (Complete specification.)
62. **Improved method of and apparatus for synchronising alternating-current dynamo electric machines, and switching them on and off mains.** John Augustin Kingdon, 28, Southampton-buildings, Chancery-lane, London.
67. **Improvements in and connected with arc lamps.** Louis Carl Henry Mensing, 166, Fleet-street, London.

JANUARY 2.

92. **An improved bracket or hanger for electric lamps.** John Peter Hebendahl, 89, Chancery-lane, London.
95. **Improvements in telephonic transmission and in the art generally of distributing or transmitting alternating currents for power and other purposes.** William Hain Eckert, 52, Chancery-lane, London. (Complete specification.
130. **Improvements in electric light appliances.** Alfred Henry Wildy, 18, Buckingham-street, Strand, London.
135. **Improvements relating to the transmission of electric currents and to conductors therefor.** Michael Idvorsky Pupin, 45, Southampton-buildings, Chancery-lane, London. (Complete specification.)
139. **Improvements in telephone exchange systems.** Romaine Callender, 45, Southampton-buildings, Chancery-lane, London. (Complete specification.)
140. **Improvements in telephone exchange systems.** Romaine Callender, 45, Southampton-buildings, Chancery-lane, London. (Complete specification.)

JANUARY 3.

191. **Improvements in dynamos.** Nathaniel Shepard Keith, 24, Southampton-buildings, Chancery-lane, London.
192. **Improvements in electric drills or reciprocating motors, and in dynamos for working the same.** Nathaniel Shepard Keith, 24, Southampton-buildings, Chancery-lane, London.

JANUARY 4.

205. **Automatic compensators for neutralising the magnetic effects of dynamos and motors on board ships.** Sydney Evershed, 1, Woodfield-road, Harrow-road, London.
207 **Improvements in electrical transformers and apparatus connected therewith.** Sebastian Ziani de Ferranti, 27, Charterhouse-square, London.
214. **Improvements in apparatus for transmitting movements for actuating mechanism at a distance, for telegraphing, indicating, and for analogous purposes.** Stephen Alley, 87, St. Vincent-street, Glasgow.
249. **Improvements in electric switching apparatus, more especially intended for use on electrically-propelled vehicles carrying both the source of electricity and the motors.** Frank King, 47, Lincoln's-inn-fields, London.

JANUARY 5.

267. **An improved electric bell indicator.** William Valentine Hunt and William Hunt, 21, Sangora-road, Clapham Junction, London.
294. **Improvements in type-printing telegraphic apparatus.** William Phillips Thompson, 6, Lord-street, Liverpool. (Johann Kustermann, Germany.)

JANUARY 6.

334. **Improvements in fastenings for electric light shades or globes.** Philip Henry Jauncey, 51, Lozells-road, Birmingham.

SPECIFICATIONS PUBLISHED.

1892.

23460. **Electromotors.** Barnett.
23774. **Electric arc for lighting.** Niewerth.

1893.

601. **Electric incandescent lamps.** Hughes.
775. **Electric arc lamps.** Conrady.
1661. **Electrolytic apparatus.** Andreoli.
1683. **Electric arc lamps.** Lott.
2272. **Electric light hangers.** Holt.
3118. **Electrical conductors.** Edmunds.
3119. **Forming solid ends on electrical conductors.** Edmunds.
3152. **Electrical pendulum indicator.** Beal.
7600. **Electrical heating apparatus.** Salomons.
16226. **Electric cars.** Egger and others.
18064. **Electric switches.** Edison and Swan United Electric Light Company, Limited, and Bell.
18990. **Electrically heating or working metal.** Thompson. (Coffin.)
20408. **Ear-pieces for telephone receivers.** Kinniburgh.
21324. **Electric cables.** De Ferranti.
21628. **Telegraphy.** Delany.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	2⅝
— Pref.	—	2¼
Charing Cross and Strand	—	5
City of London	—	11½
— Pref.	—	13¼
Electric Construction	—	1⅜
House-to-House	5	2
India Rubber, Gutta Percha & Telegraph Co.	10	22½
Liverpool Electric Supply	5	6½
	3½	4⅝
London Electric Supply	5	1
Metropolitan Electric Supply	—	8 3/16
National Telephone	5	4¾
St. James', Pref.	—	8½
Swan United	3½	3¼
Westminster Electric	—	5¼

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NOTES.

Afghanistan.—The electric light and the telephone are used in Cabul.

Sweet Violin. — Violin playing by electricity is reported as the latest move.

Hyde Park.—The new sanitary building erected near the Marble Arch is lighted by both electricity and gas.

Electric Cranes.—The two electric cranes now fitted on the Town Quay at Southampton are reported to have stood all tests.

The Dangers of Coal Gas.—A manhole cover in connection with the St. Pancras electric lighting mains in Endsleigh-gardens was blown up the other day.

The Leeds Tramways.—The *Yorkshire Post*, in a series of articles on the future of the Leeds tramways, discusses the various systems of traction in use in different countries.

New Calendar.—We have to acknowledge receipt from Mr. C. Rettie of a wall calendar, showing the application of electricity to shiplighting and electric traction on tramways.

Traction at Bristol.—The Sanitary Committee of the Corporation have under consideration a proposal to introduce the trolley system on the projected extension of the tramways.

Society of Arts.—On Monday, at 8 p.m., the first Cantor lecture on "The Detection and Measurement of Inflammable Gas and Vapour in the Air," by Prof. Frank Clowes, D.Sc., will be delivered.

Dynamo and Transformer Construction.—Mr. James Swinburne is now giving a course of lectures on "Dynamo and Transformer Construction" to the students of the Electrical Standardising, Testing, and Training Institution.

Personal.—Mr. Gisbert Kapp is now in Germany, where he has gone to inspect the electrical plant contracted for by Messrs. Siemens and Halske for the Cape Town Corporation. The machinery comprises a combined steam and water-power plant.

Cost of Traction on Tramways.—The cost of haulage on the lines of the London Tramways Company, whose system of 23½ miles, with the exception of three miles operated by cable, is worked by horses, amounted to 8¾d. per mile run during 1893.

Award.—Mr. Robt. Thompson, chairman of the North-East Coast Institute of Engineers and Shipbuilders, announced on Tuesday that Mr. J. Brentnall Duckitt was a successful candidate for graduate award for his paper on "Continuous-Current Dynamos."

Book Received.—"Electric Waves," being researches on the propagation of electric action with finite velocity through space; by Dr. H. Hertz. Translated by Prof. D. E. Jones, B.Sc., with a preface by Lord Kelvin, P.R.S. (London: Macmillan and Co. 10s.)

The Institution.—An ordinary general meeting of the Institution of Electrical Engineers will be held on Thursday next, the 25th inst. A paper by Mr. W. H. Preece, C.B., F.R.S., past-president, will be read on "Notes of a Trip to the United States and to Chicago, 1893."

The Antwerp Exhibition.—On Saturday a meeting of the London Executive Committee of the forthcoming international exhibition at Antwerp was held at the Mansion House. A public meeting is to be held at the Mansion House on the 25th inst., at three o'clock, to further advance the interests of the British section.

The Electro-Harmonic Society.—As stated in our last issue, the next smoking concert of this society will take place on Friday next, the 26th inst., in the Banquet-room of the St. James's Hall Restaurant, Regent-street, W. The programme of the concert, which will commence at eight o'clock, is an attractive one. It was printed in our last issue.

The Junior Engineering Society.—To-morrow (Saturday) afternoon, the 20th inst., at 3 p.m., a visit will be paid to the engineering laboratories, workshops, etc., of the Battersea Polytechnic Institute, Battersea Park-road, S.W. At the last visit of this society an inspection was made of Mr. Peter Mumford's Royal Flour Mills, Vauxhall.

The "Medical Battery" Company, Limited.—On Wednesday, at Marlborough-street Police Court, Mr. Hannay resumed the hearing of the charges of conspiracy to defraud made against Messrs. Harness, M'Cully, and Hollier. The case for the prosecution was concluded last week, and on Wednesday the case for the defence was commenced.

Berliner's Telephones.—A new illustrated list of Berliner's telephones has been issued by Messrs. O. Berend and Co. The list deals with telephone sets for domestic use, improved Blake transmitter combinations, battery sets, transmitters and receivers, and telephone exchanges, etc. We are informed that the firm's telephones received the only reward given for microphones at the Chicago Exhibition.

New Type of Reflector.—We have received particulars from Messrs. J. Gill and Sons, of West House Works, Heckmondwike, of a new reflector arrangement for lighting, applicable both to gas and electrical illumination. It is claimed that this appliance absorbs all tobacco smoke, and that it transforms into pleasant and agreeable rooms those places which are under ordinary conditions stuffy and uncomfortable.

The Pacific Cable.—Mr. Sandford Fleming, who is now on his way back to Canada after paying a visit to the Australian Colonies, is enthusiastic about the scheme for an "all-British" cable across the Pacific. Mr. Fleming figures it out that messages could be sent between England and Australia over the proposed Canadian Pacific cable for about 3s. 3d. a word, as against the present rate of 4s. 9d. a word over the Indian Ocean wires.

Lines of Equal Magnetic Declination.—The *Colliery Guardian* has forwarded us a map showing lines of equal magnetic declination or variation of the compass corrected to the beginning of January 1. The lines, which are shown in red on the map, depend, as in several past years, on the magnetic survey of the kingdom undertaken by Profs. Rücker and Thorpe, as published in the *Philosophical Transactions* for the year 1890.

Electric Traction at Bristol.—A deputation from Bristol, representing the Kingswood and St. George's Urban Sanitary Authorities and the Bristol Tramways and Carriage Company, Limited, have paid a visit to Walsall to inspect the overhead electric system of the South Staffordshire Tramways Company, in view of the fact that arrangements are in progress for the introduction of a similar system in the two districts in question.

The Santiago Mining Exhibition.—The Department of Science and Art has received through the Foreign Office a despatch from her Majesty's Minister in Chili, in which it is announced that the opening of the Santiago (Chili) Mining and Metallurgical Exhibition, 1894, has been postponed from April until September of this year, but

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that, notwithstanding this deferred date of opening, all proposed exhibits can at once be forwarded to Santiago.

Regent-street Polytechnic.—On Monday evening a social reunion and distribution of prizes to the students of the mechanical and electrical engineering classes took place at the Regent-street Polytechnic. There are, it seems, some 350 pupils in the former class under Mr. Henry Spooner, and 300 in the latter under Mr. W. Hibbert. Attached to the electrical department are two physical laboratories, one for elementary and one for advanced students.

Telephonic Communication with Lightships.—The last of the difficulties which have so long stood in the way of the completion of the arrangements for the telephonic connection of the Goodwin lightships with the shore are now removed. The Ramsgate Corporation have granted the necessary permission for carrying the wires through to the town post office. The connection will be direct between the North Sand Head lightship and the Ramsgate Post Office.

Electric Traction at Hartlepool.—We understand that a syndicate has been formed which has purchased the Hartlepool tramways for the purposes of equipping them with the overhead system. The promoters appeared before the Works Committee of both West Hartlepool and Hartlepool Corporations on the 11th inst., and after having explained their intentions, the committee decided to report in favour of the proposition to the Council. We are informed that the tramway system is to be considerably extended.

The Hermite Process.—Preparations for the forthcoming experiments in electrical sanitation are proceeding at Worthing, and operations will probably be commenced about a week or ten days hence. When all the arrangements have been completed, M. Hermite will come from Paris to superintend the tests, which will probably be witnessed by a large number of people interested in sanitary science, applications for permission to be present having been received from many parts of the country.

Derry.—The secretary to the Port and Harbour Commissioners has communicated to the latter a letter from the Board of Trade relative to the inspection of cattle after sundown by means of the electric light. At present, when cattle arrived in the port for shipment to England or Scotland after sunset, they cannot be inspected, and must be kept for 24 hours longer, at expense to the shipper. The secretary has been instructed to write to Belfast to know what was actually required in the way of electric light, and then to ask the Corporation of Derry on what terms they could supply the light on the quays.

South Wales Engineers.—A new building in Park-place, Cardiff, which is now to be the headquarters of the South Wales Institute of Engineers and the Monmouthshire and South Wales Coalowners' Association, was opened last Friday. Besides being lighted with gas in certain parts, the building has been equipped with a complete electric light installation by Messrs. Verity and Co. It is intended to have the electric supply from the Corporation system when it is complete and in working order, but at present it is obtained from Cardiff Castle, through the kindness of the Marquis of Bute. In the evening, a conversazione was held. Prof. A. L. Selby, M.A., in the absence of Principal Jones, gave a demonstration of the projection of the electric arc, and much interest was centred in the various exhibits.

The Government and Telephony.—Notice of motion has been set down by Mr. Provand, M.P., for next session of Parliament that a select committee be appointed to enquire into and report upon the proposed arrangements between the Post Office and the telephone companies as to the working and all other agreements between the telephone companies; and generally on the future policy of the Post Office with reference to the extension of the telephone service. The *Pall Mall Gazette* understands that although the terms of the agreement between the Post Office and the National Telephone Company have not yet been submitted to Parliament, they have been practically settled, subject to ratification by the Department after the House of Commons has had the promised opportunity of discussing them.

The Halifax-Bermudas Cable.—A *Times* correspondent states that strong pressure is being brought to bear upon the Canadian Government by business men in Canada to induce it to grant the extension of the Halifax-Bermuda cable to Jamaica. The leading shippers have been interviewed on the subject, and they hold the extension of the cable to Jamaica and other islands to be absolutely essential to the development of Canadian trade. Four steamers a month are now running from Halifax to those islands, but business is very much restricted by the high telegraph rates charged, and by the fact that the daily quotations of prices published in the West Indian newspapers come from New York. The extension of the Bermudas cable would make it possible for the Canadian market prices to be published in the West Indies side by side with the American quotations; and with the advantage of cheaper cable rates Canadian trade would be largely increased.

The Newport Tenders.—The Parliamentary and Improvement Committee of the Newport Town Council sat for some time on Tuesday to reconsider the tenders sent in for electric lighting plant. It will be remembered that at the monthly meeting of the Corporation last week the Electric Lighting Sub-Committee recommended the acceptance of the tender of Messrs. John Fowler and Co., although their tender was more than £2,000 above that of Messrs. Crompton and Sons. The Corporation refused at that meeting to adopt the recommendation of the committee, but referred the matter back so that Messrs. Crompton might be heard in answer to certain observations made with reference to their plant by the consulting engineer. One of the firm of Messrs. Crompton and their South Wales representative, Mr. Howell, of Llanelly, attended before the committee, and a protracted discussion took place, but no decision was arrived at, the matter being adjourned for a week.

Royal Meteorological Society. — The annual meeting of this society was held on Wednesday evening at the Institution of Civil Engineers, Westminster, Dr. C. Theodore Williams, president, in the chair. The council in their report stated that the society had made steady and uninterrupted progress during the year, there being an increase in the number of fellows, and the balance of income over expenditure being greater than in 1892. They also reported that Dr. C. Theodore Williams, previous to vacating the office of president, had expressed a desire for the formation of a fund for carrying out experiments and observations in meteorology, and that he had presented to the society the sum of £100 to form the nucleus of a research fund. The president, Dr. C. Theodore Williams, in his valedictory address gave an account of the climate of Southern California, which he made most interesting by exhibiting a number of lantern slides. Subsequently, Mr. R. Inwards, F.R.A.S., was elected president for the ensuing year.

Fire Brigade and Telephony.—Captain Simonds, in his report for 1893, issued on Monday, says: "Early in the year an important change was made in the system of

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providing against a breakdown in the direct telephonic communications between the headquarters and the superintendents' stations. For this purpose there used to be loop lines and instruments connecting each district with those adjacent to it. This method necessitated the message being repeated four times, causing considerable delay and increasing the risk of errors being made. Duplicate direct wires between headquarters and each superintendent's station, run on different routes to the original wires, have been substituted for the loop-lines, and are found to be much more convenient. A signalling apparatus, in connection with the telephone wires, has been established throughout the A district, whereby considerable time is saved in getting help on to fires. The telephones at the Manchester-square station have at the same time been rearranged. These changes will be extended to the other districts as soon as the necessary instruments can be supplied."

Accumulator Traction.—Mr. L. Epstein has written a letter to the *Standard* in reference to an article on different systems of electric traction that appeared in the leading columns of that paper on the 6th inst. He says: "It seems to me that too much stress is laid by the writer upon the objection to the use of accumulators on account of their great weight and the cost of renewing them. With regard to the first, it should be remembered that the additional weight of an accumulator car (an electric car being in any case much heavier than a car drawn by horses) is only about 20 per cent., and, as regards the cost of renewal, practical working has established the fact that the maintenance rate of 1½d. per car mile leaves a very fair margin of profit. Now, all the other items of expenditure being known, and accumulator-makers being willing to undertake the maintenance, it can be shown that the cost of working a tramway line by accumulators is not more than if the same line be worked by a system in which the current is conveyed from a distance. As regards the cost of installation, an accumulator line compares favourably with a direct system, such advantage being, of course, still more marked in the case of conversion of an existing horse tramway."

The Fatal Accident in Blackfriars.—The inquest as to the death of Frederick W. Ball, who was killed at the Blackfriars station of the London Electric Supply Corporation on September 12 last, was resumed and concluded on Monday at Guy's Hospital. The enquiry had been adjourned twice for the attendance of Ernest Meech, who was injured by the electric current, and had since been in hospital. After Meech had given evidence, the jury ultimately returned a verdict that they were of opinion that Ball met his death accidentally by electricity; that had proper precautions been taken to provide the men with gloves the fatality might have been averted; that the rules and regulations should have been printed; and that Meech should have been more competent. With regard to the suggested use of indiarubber gloves, there is little doubt that the provision of gloves would induce a false feeling of security, and dirt on the gloves might lead to a man receiving a fatal shock. As to printed rules and regulations, the men engaged in the transformer stations are experienced and thoroughly understand their duties, knowing full well that they must not touch the transformers when the current is passing. This is the main safeguard.

The Liverpool Electric Railway.—Mr. Wm. B. Forwood, the chairman of the Liverpool Overhead Railway Company, has addressed to the secretary of the Electric Construction Company a letter of which the latter will be justly proud, and particularly Mr. T. Parker, the engineer and works director. In fact, it would be difficult for a higher compliment to be paid than that contained in the communication in question. Mr. Forwood and his colleagues express their satisfaction with the manner in which the company has fulfilled its contract with the electrical equipment of the railway. The directors state that the machinery has been well and substantially made; that it is economical in working; and that its efficiency may be gauged by the fact that during the 10 months the line has been opened a five minutes' service of trains has been run, and 96 per cent. have been on time. They also say that they considered that the generating station has proved its capacity and reliability, and they have, therefore, relieved the contractors of its charge. The directors are of opinion that these excellent results are very largely due to the scientific skill, thorough and untiring industry of the works director, Mr. Parker, to whom they asked the secretary to convey their thanks.

Electric Traction in Birmingham.—A short time ago the Central Tramways Company approached the Public Works Committee of the Town Council with a view to obtaining sanction to the adoption of the trolley system of working electric cars. The committee were also asked to inspect the working of the system at Walsall. Members of the committee recently visited Walsall, but on Monday the committee decided that they could not consent to the application. The principal objection is said to be the unsightliness of the poles and wires. In this connection a Birmingham paper states that the directors of the tramway company are much disappointed at the committee not consenting to the adoption of the overhead system. Continuing, the same paper says: "The present cars, worked by accumulators, entail a considerable loss. In view of this it was in contemplation to reduce the service to one of four cars, making a journey each way every half-hour during the period between now and the autumn, by which time the new system could have been brought into use. This would have lengthened the life of the accumulators at present belonging to the route, so that no additional capital expenditure would have been entailed for fresh ones. Under the new circumstances we learn that it is not improbable that the service of electric cars will have to be reduced to three vehicles."

The Testing of Electrical Instruments.—The Physical Laboratory Testing Department of Owens College, Manchester, is prepared to test a limited number of electrical instruments, free of charge, under certain conditions. The results will be embodied on a certificate which will bear the college stamp, and the certificate will only contain a statement of the results of experiments made with the instrument, and no opinion will be expressed as to its value or construction. The electrical standards of the laboratory will be compared from time to time with the standards of the Board of Trade, and every effort will be made to ensure accuracy; but the college incurs no responsibility with respect to the correctness of the figures given in the certificates. The college will test direct-current meters up to 100 amperes, and give the corrections to the instrument both for descending and ascending currents at definite points, which, for each instrument, shall number not less than three and not more than 10. Alternate-current meters will also be tested as far as the resources will allow. Voltmeters will be tested up to 200 volts, and before long the testing may be carried to 1,000 or 2,000 volts. Clark cells will be compared with a number of standards, the E.M.F. of which will be determined from time to time. Instruments of different kinds from those mentioned will be tested as far as circumstances will permit. All enquiries on the subject should be addressed to Prof. Arthur Schuster, Owens College, Manchester, and headed "Physical Laboratory Testing Department."

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Wator Power in India.—Some time ago a committee consisting of Profs. W. C. Roberts-Austen, W. C. Unwin, and G. Forbes, and Colonel J. Pennycuick, was appointed to consider the question of the utilisation of the water power derived from the Periyar Irrigation Works. This committee is reported to have concluded its investigations and issued its report. The committee is of opinion that by the adoption of the arrangements proposed, motive power can be supplied in the towns of Madras, Madura, and Trichinopoly at an annual cost of £3, £2, and £1. 10s. per horse-power respectively. Colonel Pennycuick deals with the hydraulic machinery. His calculations lead to the result that at the works the capital cost per horse-power would not exceed £4, or the annual charge about 10s. per horse-power. The motors, according to Prof. Unwin, should be either Girard turbines, as used at Turin, or tangent wheels. Prof. Forbes, in his report, deals with the cost of the electrical part of the works, including the generation of electric current and its transmission to certain points. He decides in favour of an alternating current. For general purposes he prefers the two-phase system, and bases his calculations on that. He suggests that the type of machine required is that each motor should be 5,000 h.p. Prof. Roberts-Austen deals with the question as to whether it is possible to obtain aluminium by electrical energy, and here it is only a question of the material whence the aluminium is to be extracted.

Electricity on Warships.—The Brazilian cruiser "Nictheroy," to which reference was made in a previous issue, is fitted with a complete electrical equipment. The plant consists of two 10in. × 10in. 50-h.p. Ideal engines, each belted to a standard General Electric compound-wound bipolar dynamo of 30 kilowatts, or 540 16-c.p. lamps capacity each. Upon a slate switchboard near the dynamos are mounted a full complement of marine volt and ammeters, and a double-pole knife switch for each circuit leaving the board. There are five circuits for the 300 incandescent lamps installed, two for the search-lights, and one for the 50-h.p. motor. The switchboard is so arranged that either dynamo can be used either on the motor or lighting circuits. The wires from the board are led through a special moulding, and wherever exposed to moisture are provided with a leaden armour. All the appliances such as switches, receptacles, etc., are of the same watertight pattern as used on the United States war vessels, as are also the fixtures, portable lights, deck and battle lanterns. For the last a separate circuit has been provided. They can thus be carried from place to place, and connected at different convenient points. On the roof of the pilot-house, says the New York *Electrical Engineer*, is set the automatic 30in. search-light, similar in size and intensity to that on Mount Washington, which throws a beam of light which can be seen from Portland, Me., 85 miles away. That on the "Nictheroy" is flanked on both sides by Hotchkiss rapid-firing machine guns, and can project a beam of light from its spherical concave mirror sufficiently powerful to allow light-coloured objects to be easily distinguished at 6,000 yards. It is furnished with a diverging lens, by which the beam can be diverged horizontally to cover a wide space. The lamp takes a current of 100 amperes to produce an effective arc between the points of the two, one and a quarter inch carbons. In the pilot-house is a small switchboard from which the search-light is electrically controlled, and may be moved in any direction horizontally or vertically. The small motors which do this work are concealed in the iron pedestal of the projector. The after search-light is used as an auxiliary. It is of the same pattern, but has a mirror of only 12in., and is hand controlled. The "Britannia" is also fitted with one 24in. and one 12in. projector. A 50-h.p. motor is used to train the dynamite gun, which can be raised, lowered, or turned to left or right as required. A system of electric signals completes the electrical equipment.

The Late Prof. Hertz.—The death has recently occurred of Prof. Heinrich Hertz, who was born at Hamburg in 1857. He studied physics at Munich, and afterwards at Berlin under Prof. Helmholtz. He then took up his abode as a lecturer at Kiel, and two years later was made professor at the Technical College of Karlsruhe, where his world-renowned experiments were instituted. Hertz's investigations deal exclusively with the relations between light and electricity. Maxwell had handled the subject theoretically, and already in 1865 had developed his electromagnetic theory of light. In connection with this enquiry, it now became a question of measuring directly, by means of experiments, the rapidity of the transmission of electric action; for instance, the charging of a Leyden jar or the motion of a magnet. Hertz was able to prove experimentally that electric waves, like light-waves, are transverse to the line of motion of the wave, and that they require a specific time for their transmission. Further experiments, in which the primary and secondary conductors were placed in the foci of two concave mirrors, showed that the electric waves followed the ordinary law of reflection. By the interpolation of a conducting screen in the path of the rays an electric separator was produced; the rays were not destroyed, but were reflected. Hertz was able to show the phenomena of refraction by the help of large prisms of asphalte or pitch. His experiments proved that there existed, not only optical waves of electricity of the well-known minuteness of waves of light, but similar ones measuring several metres, or even kilometres, in length. They proved that electric waves may be generated in connection with light-waves—that is to say, in innumerable places where their existence had hitherto been unsuspected. It goes without saying that the experimental proof of the intimate relation between light and electricity did not fail to win signal fame for its discoverer throughout the length and breadth of the scientific world. From a position of relative obscurity, Hertz leaped at a single bound to world-wide celebrity. His call, as the successor of Clausius, to the chair of physical science at Bonn, followed in 1889, an appointment which was of short duration. The Royal Society in 1890 awarded to Prof. Hertz the Rumford medal for his discoveries in connection with electromagnetic radiation.

The Midland Institute Exhibition.—The small exhibition at Birmingham, of which a description was given last week, was really very interesting and highly creditable to its organisers, and it may well serve as an example to those who are interested in the supply of electricity in other places. It was neither a purely scientific display nor a bazaar for display of goods seeking customers, but an attempt to educate the general popular mind and impress upon the visitors the practical uses which they could make of the electric current as now supplied from the mains, involving only the periodical operation of paying for the work done for them. The mode in which the current is led into the houses in Birmingham was shown in an actual connection through which passed the current working the exhibits. The meters as used were shown with their working parts exposed, and in the case of the Ferranti with a complete set of the parts separately. Two small rooms were so fitted as to tend towards a breach of the tenth commandment, who might covet without being able to obtain such pleasant surroundings. A rigidly correct follower of Ruskin might object that the true canons of art

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would not permit lights to issue from wine-decanters, pretty enough in themselves to be more agreeably occupied, but the graceful cut and ground glass chandelier in one room was equalled in beauty by the contrasted yellow and white glass of that in the other room, each of them being well brought out by their surroundings, and exhibiting all the virtues of the electric light. A number of motors were working smoothly at various operations adapted to exhibit their utility. The most notable were a dentist's drill, so perfectly under control that it suggested that even the aching void of a hollow tooth might give pleasure to a properly-balanced scientific mind—perhaps more perfectly if in someone else's head. But the neatest illustration, and one which caught the attention of the lady visitors, was a sewing-machine perfectly controlled by the pressure of the foot on the ordinary treadle; this moved a lever carrying the motor and tightening or slackening the driving cord, and at the same time actuating a brake which stops the motion of the machine. There was a great display of cooking apparatus, and illustrations of cooking without dirt and smoke, baking, and heating irons at any desired temperature, and saucepans boiling merrily away by heat contained in their bases. No doubt this display must have been very interesting to many visitors, and let us hope that some among them may be inclined to taste and try the results under their own supervision. There were, of course, plenty of illustrations of electric lighting and its management of interest to the visitors.

Electricity in Mining Operations.—A lecture on this subject was delivered on Saturday at Derby by Mr. George Fletcher, under the joint auspices of the Midland Counties' Branch of the National Association of Colliery Managers and the Technical Education Committees of the Nottinghamshire and Derbyshire County Councils. Mr. Fletcher dealt with the subject under the heads of the application of electricity to signalling, blasting, lighting, the transmission of power, pumping, hauling, and coal-cutting, and also testing for gas. After explaining how electric currents can be generated, he passed on to a consideration of transmission and utilisation of electrical energy. The lecturer then referred to pumping and hauling appliances in operation at St. John's Colliery, Normanton, and at the Abercanaid Colliery, and by the kindness of Mr. Howell he was able to lay before his hearers photographs of the plant and curves showing the efficiency of the plant. Referring to its application to mining, he pointed out that where there was any surplus power the electric lighting was certainly economical. Experiments had been tried with a view to substituting the ordinary miners' lamps by electric lamps attached to the electric mains by flexible conductors. That had, however, proved inconvenient, and what was wanted was a portable electric lamp. Many such lamps were on the market, but he was not aware that any one of them complied with the requirements. Those requirements were, he understood, low first cost, that the lamp should not be more than 4in. square, or 3lb. or 4lb. in weight, that it should maintain a light of about 1 c.p. for 14 hours at a cost of about 1d., and that it should not easily get out of order. As to its superior safety, it should not be forgotten that it lacked the advantage of being a ready means for detecting the presence of fire-damp, and it was by no means certain that the fracture of an electric lamp would not lead to an explosion if it were surrounded by an explosive mixture. True, many lamps had been broken in an explosive atmosphere without producing an explosion, but by means of experiments it had been found that explosions did sometimes result. Undoubtedly there were means of rendering it impossible for the fracture of the glass to fire explosive mixtures. In regard to its use in testing for gas, he explained that it had long ago been found that a thin platinum wire which was made to glow by the passage of an electrical current through it, increased in brilliancy when placed in an atmosphere containing a small percentage of fire-damp. That fact had been made use of in gas indicators, and it was generally admitted that this was a very delicate means of testing for gas, but that it was exceedingly inconvenient to use, and that in a great measure had prevented its adoption. The lecturer had, however, devised and provisionally protected an invention for a more convenient application of this process. In conclusion, Mr. Fletcher referred to the use of electricity for coal-cutting.

Driving Printing Machinery by Electric Motors. A noteworthy example, which we trust will soon be followed in many other cases, has just been set by the proprietor of the *Pall Mall Gazette*, who is the first in the Metropolis to introduce electric motors for driving printing machinery for the production of newspapers. There are already two or three towns in the provinces where electricity as a motive power is used in newspaper offices, but until now London has remained behind in this direction. The plant at the *Pall Mall Gazette* offices, put in operation for the first time on Tuesday, was supplied and designed by Messrs. Mather and Platt, Limited, under the superintendence of their engineer, Mr. Hardman A. Earle, M.I.E.E. It consists of two 40-h.p. motors of the Manchester type, driven off the outside mains of the Charing Cross and Strand Electricity Supply Company's three-wire system. This gives a constant pressure at the terminals of the machines of 200 volts. The motors are connected by belts to a common 4in. countershaft, divided into three sections so as to avoid the use of fast and loose pulleys. By means of handwheels, actuating a couple of clutches, either or both motors can be turned on to the countershaft at will, and made to act on the main shafting of the presses, which passes through a channel underground. The current supplied to the motors being taken from the electric lighting mains, special arrangements had to be made by Mr. W. H. Patchell, A.M.I.C.E., M.I.E.E., the chief engineer to the supply company, to prevent the load all coming on at once; and for this reason a set of resistances in parallel is placed in the circuit to each motor, so that by simply moving a lever on from one contact to another slowly, the current is supplied to the motor by degrees, allowing the engineer at the central station to make any adjustment that may be necessary to prevent fluctuations in his light. The working of the printing-presses in the production of an evening newspaper takes place, fortunately, during the daytime, before the demand for electric lighting upon the central station has reached an appreciable amount. The larger a central station is, or, rather, the more lamps it has upon its circuits, the less necessary this adjustment becomes. Half a minute is, therefore, devoted to turning the current on gradually, and when the motor has once attained its speed no alterations in the load will perceptibly affect it. Before the plant was brought into use a large portion of one day was devoted to making careful tests of the electrical and mechanical efficiency of the new plant. The belts were all coupled up to the shafting, the clutches fixed, and then one motor was started from the company's mains. This drove the countershafting round (but not the main shafting, which was disconnected), and caused the other motor to revolve as a dynamo. The current from this was then passed into a battery, and the energy it represented was carefully compared with that put into the motor from the company's mains. The results were announced to be highly satisfactory.

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PRACTICAL INSTRUMENTS FOR THE MEASUREMENT OF ELECTRICITY.

BY J. T. NIBLETT AND J. T. EWEN, B.SC.

XVI.

(Continued from page 535, Vol. XII.)

RESISTANCE, *continued.*

Jenkin's Resistance-Measurer.—Another modification of the differential galvanometer method of measuring resistances is due to the late Prof. Fleeming Jenkin. Instead of the coils being set parallel to each other, as in the Siemens instrument, they are mounted with their centres coincident and their axes at right angles, so that in plan view they form a cross, as shown in Fig. 40. They are so mounted as to be capable of rotation about their common vertical diameter, and at their centre is suspended a short magnetic needle, to which is rigidly attached a long light pointer. The position into which the coils have been turned may either be indicated on a circular scale by means of an index which turns with them, or some such arrangement as that shown in Fig. 40 may be

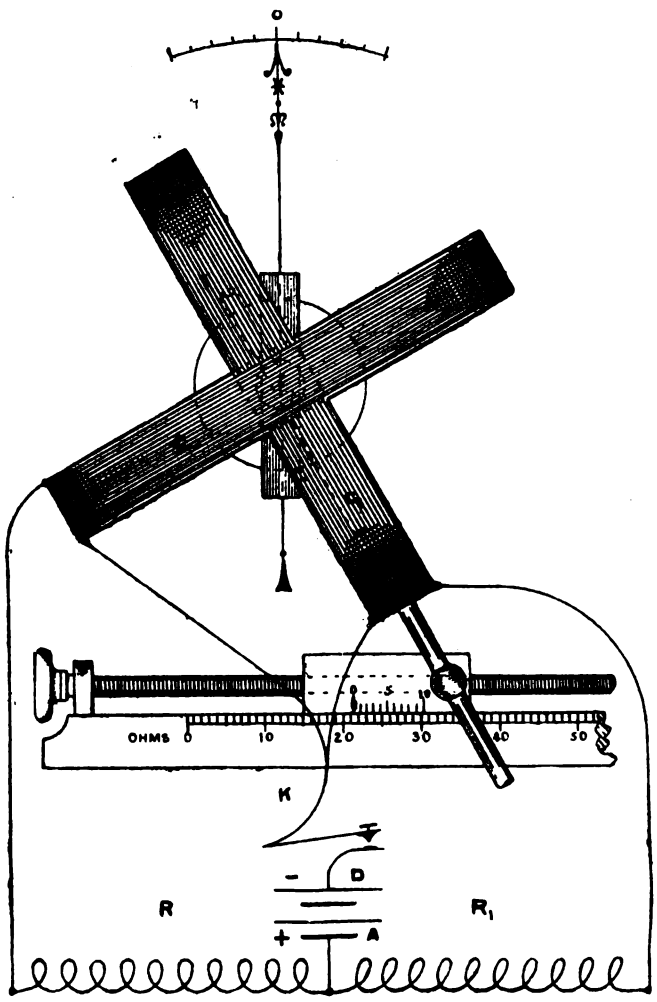

FIG. 40.—Jenkin's Resistance-Measurer. Diagrammatic Plan View.

adopted. As will be seen from Fig. 40, which shows a diagrammatic plan view of the whole apparatus and connections, the connections to the battery, the key, and the two resistances are made in precisely the same way as in the Siemens instrument; and the two portions of the current passing through the two coils tend to turn the needle in opposite directions just as before.

There are various ways of getting over the practical difficulties of arranging the two coils of this instrument. In one method the two cores on which the coils are to be wound are made of the same size, and rigidly fixed together so as to intersect each other; the two wires are then wound in alternate layers, so that the two coils when completed have their wires interwoven at the crossings. Another method is to make the one coil so much smaller than the other as to be just able to pass through it, and to wind the two in such a manner that with equal currents the magnetic effects on a needle suspended in the usual way at their common centre will be exactly the same. The coils are then mounted, as before, on a vertical axis, the two coils being at right angles to each other and the one inside the other.

A third, and perhaps the best, of the three methods is to make the two coils exactly equal and similar in every way, and to mount them at right angles to each other on the same vertical axis, and the one on top of the other. A pair of needles are required in this case, one for each coil. These are made exactly the same, and are magnetised to precisely equal extents, and are then placed parallel to each other and attached rigidly to the ends of a stiff metal wire, equal in length to the distance between the centres of the two coils. Thus, when this arrangement is hung in position by means of the usual silk-fibre suspension, we have two horizontal needles—one suspended at the centre of each of the two coils—swinging in unison, so that the same vertical plane always passes through their directions. The magnetic moments in this case are, of course, exactly the same as if the two coils had been made to intersect each other, and had a single needle suspended at their centre, as in the first case; and by this arrangement several difficulties in construction inherent in both of the other methods are overcome.

The device illustrated in Fig. 40 for rotating the coils and indicating the position into which they have been turned to obtain "no deflection" of the needle on sending the currents through the coils, enables the value of the unknown resistance, R, to be read off directly in ohms from a suitably graduated linear scale, just as in the Siemens instrument.

The motion of the two crossed coils, C and C_1, about the vertical spindle, round which they are free to turn, is controlled by means of the long screw which is rotated by the milled head shown at the left side of the diagram. On this screw rides a block, through a guide on which passes a long rod which turns the coils about their vertical axis. This rod is always kept in the same vertical plane as the coil C_1 by means of two guides fixed beneath the coil. As is indicated in Fig. 40, the screw, the main scale, and this directing-rod are all made much longer than shown, in order to permit

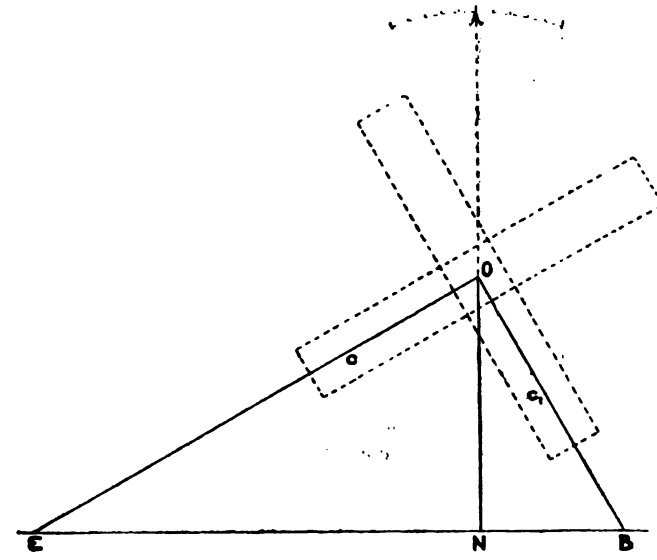

FIG. 41.—Skeleton of Jenkin's Resistance-Measurer.

of the coil C being brought round so as to be nearly perpendicular to the direction of the scale.

The value of the resistance R being measured is read off directly from the linear scale by means of the vernier engraved on the sliding block as shown.

The principle on which this depends may be explained in the following manner. Suppose that the known and unknown resistances, R_1 and R, are connected up along with the battery, A D, and the key, K, to the two coils, C and C_1, as shown in Fig. 40, and that the vernier has been adjusted to such a position, by means of the milled head and screw, that the needle pointer shows no deflection when the key is closed.

Let O in Fig. 41 represent the common axis of the two coils, and E B a line drawn parallel to the linear scale through the guide on the vernier block. Let O E and O B represent the directions of the two coils, C and C_1, respectively (B repre-

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senting the guide on the vernier block), and let O N be drawn perpendicular to E B.

Now since the needle is not deflected when the circuit is closed, the magnetic effects of the two opposing currents in the coils, C and C_1, must be exactly equal; and, therefore (according to the principle of the ordinary galvanometer), the currents in the coils are proportioned to the sines of the respective angles between the coils and the needle. But (on the principle of the Wheatstone bridge) the currents themselves are inversely proportional to the resistances of their respective circuits.

Thus we may write

$$\frac{\text{Resistance of R + C}}{\text{Resistance of } R_1 + C_1} = \frac{\text{Current in } C_1}{\text{Current in C}} = \frac{\text{Sin B O N}}{\text{Sin E O N}} = \frac{\text{Sin B O N}}{\text{Sin O B N}} = \frac{\text{N B}}{\text{N O}};$$

or to write this in another way,

$$\frac{\text{Resistance of R + C}}{\text{N B}} = \frac{\text{Resistance of } R_1 + C_1}{\text{N O}}.$$

But whatever the position of the coils, the distance N O is always the same, and the value of the resistance $R_1 + C_1$ is also constant and known. Therefore, from the above relation it is evident that on the same scale on which the distance N O represents the resistance $R_1 + C_1$, the resistance of R + C is similarly represented by N B. Thus, equal increments in the resistance of R + C are represented by equal increments of the distance N B; and the magnitude and value of the divisions on the linear scale are readily obtained from the above proportional relations. Further, since the resistance of the coil C is a fixed and known quantity, the position of the vernier zero can be so adjusted on the sliding block that it deducts the resistance of C from the length N B on the scale, and reads off the value of the resistance R in ohms direct. In the example shown in Fig. 40 the value of R is 21·2 ohms.

(To be continued.)

FAULTS IN DYNAMOS.

(Continued from page 43.)

D. Open Circuit in the Internal or External Circuit.—When the fault is in the external circuit, an incandescent lamp inserted between the terminals of the dynamo after the main leads have been removed will burn steadily; otherwise, the fault must be looked for in the internal circuit in the manner following:

(*a*) *Disconnection in the Field Coils.* — By means of a battery and galvanometer or bell connected as in Fig. 1 this fault can be readily detected, care being taken to first detach the ends of each coil. A disconnected coil will not cause any deflection of the galvanometer or sound of the bell. After each coil has been tested, all the connections in circuit should be carefully examined and the contacts scrupulously cleaned.

(*b*) *Disconnection in the Armature Circuit.*—To determine whether a break exists in the armature circuit, the wires connecting the coils with the collector should first be removed and each coil tested with the apparatus as in Fig. 1. If with one of the coils tested in this way there is no deflection of the galvanometer, there is a want of continuity, which should be tested for as follows: The dynamo should be started, and two points, *c d*, of the commutator, Fig. 4, comprising between them several bars, should be touched with a wire, *a b*. If the machine begins to give current a spark will show on the commutator between the two ends of the wire, *a b*, and thus indicate that the fault is between those two points. If no sparking occurs, other points of the commutator must be touched with the wire, *a b*, until sparking does occur. Immediately a spark shows, however, the dynamo must be stopped to avoid damage to the commutator and armature. The faulty coil can then be detected by the traces of burning which will appear upon the bar corresponding to it. In the majority of cases this fault is more often due to a bad contact than to rupture of the conductor, and it has a very mischievous effect upon certain bars of the commutator by reason of the strong sparks which are produced when the brushes pass over those bars. It is necessary, therefore, whenever the bars wear unequally to test all the connections between them and the coils corresponding to them, so that the fault or faults may be detected and repaired.

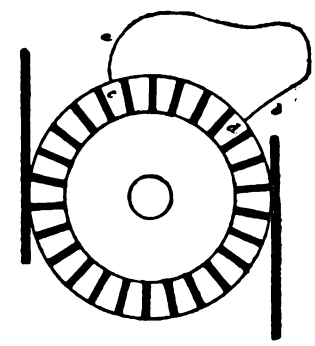

Fig. 4.

(*c*) *Brush Not Making Contact.*—A simple examination of the brushes is sufficient to show this defect.

(*d*) *Disconnection in the External Circuit.*—When the test described under D shows that the fault is in the external circuit, examination must be made of all the apparatus in circuit—terminals, cut-outs, lamps, etc.—to see if they are in good order, or making good contact, as the case may be. This examination (made, if possible, with a battery and galvanometer) should include the switchboard, etc., and if it does not indicate the locality of the fault, all the apparatus should be left open, and the main leads, tested with a battery and galvanometer, joined up as in Fig. 5. One of the poles of the battery and one of the ends of the lead to be tested are put to earth, and the other end of the lead is touched with the wire *f*. If the lead is not broken, the galvanometer needle will deflect, and *vice versâ*. To locate the fault, the wire *f* should be connected with *n*, and a section of the lead tested by connecting it, for instance, at *p* with the wire *f'*. If there is then a deflection, the part *n p* is in good order, and the fault must be looked for between *p* and *q*. The wire *f* can then be joined at *r* to see if the fault is between *r* and *p*, and thus by making repeated tests the fault may be located in a section sufficiently short to permit of its being discovered on examination. In an installation where the lamps, etc., are mounted in parallel on the main leads, the working of the dynamo cannot be interfered with except by a break in the main circuit, because if any interruption occurs in a branch the lamp or lamps on it would go out, but the rest of the installation would continue to work.

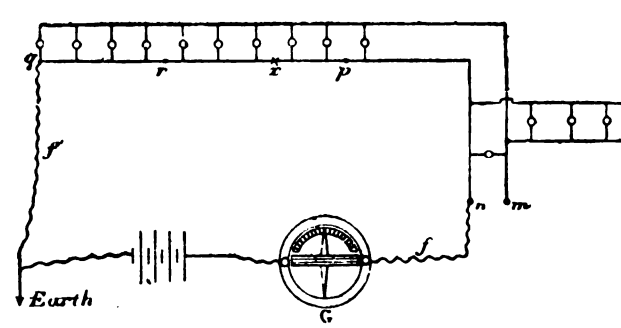

Fig. 5.

E. Reversed Field-Magnet Coils.—When the field-magnet coils have been placed on their cores in the reverse way, or their connections have been reversed, strong magnetisation of the pole-pieces will be perceived on approaching to each of them in turn a small piece of iron. If the experiment is made with a suspended magnet, each of the pole-pieces will attract the same pole of that magnet, indicating that they are of the same instead of being of opposite polarity. When the dynamo is of the multipolar type, the experiment must be made with two consecutive pole-pieces. Once the fault is detected, it may

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be remedied by rewinding the defective coil or reversing its connections.

II. PRODUCTION OF STRONG SPARKS AT THE BRUSHES.

Causes of serious sparking at the brushes are:

A. Surcharge from the dynamo. (a) Excessive voltage. (b) Great excess of current. (c) Bad insulation of the external circuit.
B. Bad adjustment of the brushes.
C. Bad state of the commutator.
D. Bad state of the brushes or brush-holders.
E. Disconnection in the armature circuit.
F. Short-circuit in the armature.
G. Defective insulation of an armature coil.
H. Weak magnetic field.

A. SURCHARGE FROM THE DYNAMO.—When the dynamo is surcharged—that is to say, when the voltage or the current is excessive—not only will violent sparking be produced at the brushes, but the field coils and the armature will be greatly heated (see III.); otherwise the belting is much too tight, and will make a noise as it slips on the pulley.

(*a*) *Excessive Voltage.*—This fault will be shown by the voltmeter. It may be due to either excessive excitation or excessive speed. In the one case the resistance should be increased to diminish excitation, as this frequently rectifies the voltage, and in the other case—which can be ascertained with a speed indicator—the engine driving the dynamo must be reduced in speed. It may also happen, when a dynamo is started for the first time, that the excess of speed is due to the pulley being of improper size.

(*b*) *Great Excess of Current.*—When a dynamo is supplying arc lamps, the surcharge may have its origin in an excess of current. The ampere-meter will show this, and the resistance in the circuit of each arc lamp can be increased until the fault disappears. If incandescent lamps are in circuit, the fault may be occasioned by there being more lamps than the dynamo is able to supply. In that event, lamps should be cut out until the defect is remedied.

(*c*) *Bad Insulation of the External Circuit.*—It is also possible that the surcharge may be due to bad insulation of the external circuit, giving rise to a considerable increase in the current furnished by the dynamo. This often occurs in rainy weather, when the external circuit is aerially carried and consists of naked wires. To locate the fault or earth contact, the main leads should be removed from the terminals of the dynamo, and the ends, *m n*, left open.

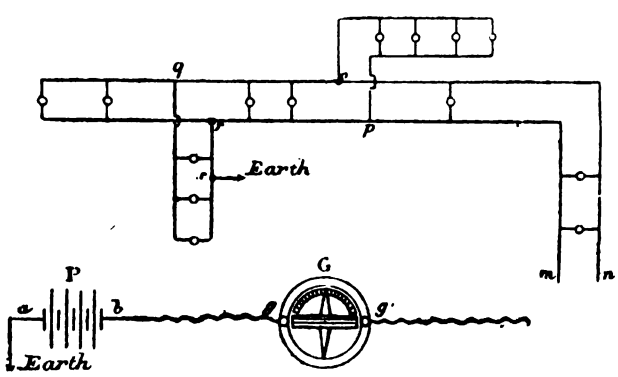

FIG. 6.

That done, the lamp circuits should be closed, as in Fig. 6, and one pole, *a*, of a battery, P, put to earth through a gas or water pipe, and the other pole, *b*, connected to one terminal, *g*, of a galvanometer, G; attaching to the terminal *g'* a wire for a purpose about to be explained. Suppose there is a loss to earth at a point, *x*, of the line or wiring. The end of one of the main leads—*m*, for example—is touched with the wire from *g'*. If there is no earth contact, the needle will not be deflected, but if there is, it will be deflected. To localise the fault, the leads should be disconnected from the branches, *o p* and *q r*, and then the lead, *m* or *n*, should be again touched with the wire from *g'*. If there is no deflection, the fault is not in the main circuit, and the branches, *o p* and *q r*, should be connected one at a time and tested as before. One of them will be faulty, and as soon as it is known which one it is, all the lamps and apparatus in that branch should be opened, and the wires *q* and *r* tested separately. Then, if a close scrutiny is made of the defective wire, the fault should be easily found. It often happens that the shunt circuits are faulty, and in such case it is necessary to disconnect them from the main leads for testing purposes.

B. BAD ADJUSTMENT OF THE BRUSHES.—When sparking is caused by bad adjustment of the brushes, it may be ascertained by displacing or shifting the brush-holders, for the reason that the sparking will vary with each movement. To obtain good adjustment, it will be sufficient to move the brushes gently backwards and forwards until a position is found in which the sparking is reduced to a minimum. If that does not have the desired effect, see whether the contacts of the opposing brushes are of exactly the same diameter, because if the brushes are not precisely in opposition they should be readjusted. A simple means of discovering this is to count the bars of the commutator, or take a measurement on each side of the space which separates the brushes from each other. If, for instance, a commutator is composed of 40 bars, and that upon which the upper brush is placed be called No. 1, the lower brush to be in its proper position should be on the twenty-first bar. Correct position of the brushes is a matter of great importance, and they should make gentle but firm contact with the collector. If they press too heavily, they soon wear out; if too lightly, they are liable to jump and produce sparking. Care should be taken that none of the wires or laminæ of the brushes are turned up out of the flat, but that they all lie evenly upon the collector, and that they and the brush-holders are thoroughly well made and fitted. The points of contact of the brushes with the collector should always be those which give rise to the minimum of sparking. At the same time, it should be remarked that these points will vary with the strength of the current.

C. BAD STATE OF THE COMMUTATOR.—This, again, produces excessive sparking. To find if the fault arises from this cause, see if the commutator turns freely, is quite round, and has no inequalities of any kind on its surface, as the latter will prevent the brushes from making good contact. To determine whether the commutator is quite round, it should be turned gently and closely examined. If not quite round, it should be made so in a lathe, either with or, when possible, without removal of the armature. Inequalities on the surface of the commutator may be small scratches caused by sparking, or be due to displacement of the bars. If the commutator is gently revolved, these inequalities may be felt with the hand, but if it is a high-tension machine, a small piece of wood had better be used. If scratches, etc., exist, they should be rubbed down with sand-paper, but emery-paper must on no account be substituted. If sand-paper is not sufficient, a file in the hands of a competent workman may be employed, but the metallic dust must be carefully removed to avoid short-circuiting the armature coils. In case the inequalities are due to wearing, from friction with the brushes, the lathe must be resorted to.

D. BAD STATE OF THE BRUSHES AND BRUSH-HOLDERS.—If these are in a defective condition, there will be bad contact between the brushes and commutators, and consequently much sparking. To ascertain this, proceed as in B, and remedy the fault by readjustment and cleaning.

(To be continued.)

INSTITUTION OF ELECTRICAL ENGINEERS.

INAUGURAL ADDRESS OF MR. ALEXANDER SIEMENS, M.I.C.E. (PRESIDENT).

(Concluded from page 47.)

Originally the steam-dynamos were designed for use on board ship, where economy of space is of importance, and great credit is due to the Admiralty for introducing very early a system of testing which has been no small incentive to all concerned to improve the dynamos as well as the steam-engines. In these tests the dynamo is run for a number of hours at its maximum output, and no part of it

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must get hotter than the surrounding air by more than a prescribed number of degrees of heat. Nothing could be simpler than this test, and at the same time it is the most reliable way of finding out whether a dynamo has been constructed suitably for its work. During the same run the water is measured which, in the form of steam, is supplied to the engine, and the relation between the water consumed and the electrical energy supplied to the electrical circuits determines the merit of the steam-dynamo tested.

By far the most important connection between mechanical and electrical engineering is, however, the transmission of power, which has of late acquired so much prominence. If the first stage of the development of the electrical industry was closely connected with telegraphy, the second step may be said to have been taken when electric lighting was introduced, and now it seems that transmission of power is the problem which electrical engineers have to grapple with in the near future. The success of electric tram lines has undoubtedly contributed to direct general attention to the transmission of power by means of electricity, but great care will have to be exercised so as not to start in a direction that can lead to no practical results. Many schemes have been started to introduce electricity as the motive power on the main lines of railway, and to accelerate at the same time the speed of the trains very considerably, even up to 200 miles per hour. It would be rash to say that such a speed will not be attained some day, but in my opinion none of these schemes can be carried out on a commercial basis with the means at present at our disposal. Trebling the speed of the trains necessitates a radical alteration in the laying of the permanent way, a thorough reconstruction of the carriages, and demands an amount of power that we have no means at present of estimating accurately, nor have we motors that could produce it with a moderate weight. Even if these obstacles are overcome, the enormous capital outlay could only be justified if a very frequent service was kept up, as in the case of successful electric tramways. In most schemes it is, in fact, proposed to run single carriages at short intervals between important towns, but up till the present time it has not been possible to convince capitalists that such a service would pay, either between Vienna and Budapest, or between Chicago and St. Louis, which are the most notable instances of such schemes.

Leaving these ambitious projects out of consideration, enough scope remains for the development of electric traction in this country to render a healthy activity in this branch of our industry probable for a number of years; and the report of the Hybrid Committee which sat last year has removed, let us hope, a very serious obstacle to electric traction. As the rules which the Board of Trade has drawn up in accordance with the instructions of this committee are still under consideration, it would obviously not be in order to criticise the version that has been published; it would, however, be hampering the industry if too many details were too accurately prescribed. In this connection it must not be forgotten that in the past the industries of this country have been developed, to the great advantage of the nation, with very little legislative interference; and it would at present be premature to make the regulations about electric traction too stringent, as the working out of this branch of electrical engineering is by no means completed.

Besides traction, there is the distribution of power, in which mechanical engineering is of the greatest influence on the successful application of electricity. It is, of course, a purely electrical problem to deliver your current either at a standard voltage, or in a constant quantity, at all points of your network of mains; but the application of the motors to the work they are required to do, and the determination of their dimensions, involve principally mechanical considerations. How much there is still to be done in this respect was made apparent during the discussion of Prof. Forbes's paper on the proposed utilisation of water power at the Niagara Falls. Although the prevailing opinion seemed to be that for transmission to a great distance alternate currents only can be utilised, I believe that of the actually established long-distance transmissions the greater part are worked with continuous currents. No hard-and-fast rule can apparently be laid down that either the continuous or the alternate current should be preferred in all cases where power has to be transmitted to a distance; and in judging of the merits of the two systems the proper conclusion can only be arrived at if the commercial aspect of the case is allowed to decide the question.

The installation of rotary-current motors at the Frankfort Exhibition driven by the water power at Lauffen was undoubtedly an engineering success, and served very well for the purposes of an exhibition; but nobody has attempted to do everyday work on the same lines, for the simple reason that it would have been much cheaper to produce the power in Frankfort by steam-engines than pay the commercial interest on the outlay that had been necessary to establish the transmission from Lauffen. The generating plant of this installation is now used for the lighting of Heilbronn, and there are a few other instances where rotary currents are used for long-distance transmissions; but, as I said just now, it would be wrong to generalise by preferring either the one or the other method of transmission in all cases.

Another great field for electric motors is just being opened by their introduction for distributing power in works, with a view of abolishing shafting, leather belts, and other intermediate gearing, and of giving each lathe or other tool an independence that cannot be attained under the present system. A most interesting paper on this subject was read by M. Castermans before the Society of Engineers in Liège in August, 1892, in which he compares in detail several proposals for distributing power in a new small-arms factory that has since been erected at Herstals. The result he arrived at was that with electrical motors he could exert on the working machines 70 per cent. of the power generated by the main engine, while the next best other method gave only 63 per cent., when the shops were working at their full capacity.

In these problems, again, mechanical engineering questions decide whether the application of electricity is justifiable; and it is quite apparent that an electrical engineer requires to be well versed in a variety of subjects if he wishes to keep in the front rank. Fortunately for our profession, the question of technical education generally has received particular attention during the last quarter of a century; and omitting all reference to other occasions when this subject has been brought before this Institution, I will only remind you of the eloquent address of Prof. Ayrton, which no doubt is still fresh in your memory. It will, therefore, not be necessary for me to repeat his lucid exposition of the transition from the former system of pupilage to the modern one of educating the budding engineers in colleges and their laboratories, which has supplemented, and to a great extent supplanted, the old one. No doubt this altered system of education is capable of producing a class of men who are well adapted to explore the untrodden fields of applied electrical energy, where the problems constantly demand a thorough knowledge of scientific principles; but, in combination with this, an equally entensive acquaintance with practical possibilities is requisite. This most important co-operation of science and practice is essential for all real success, and no doubt it appears to be superfluous to insist on the necessity of bearing this in mind; but a perusal of patent specifications will at once convince you that either the one or the other factor is sadly wanting in many would-be inventors. Years ago it was science that was most conspicuous by its absence in these documents; but in the present time it is very often obvious that the inventor has no clear conception how his invention could be carried out so as to make it useful to mankind, and even fails to see the obvious impossibility of realising his ideas in the way he claims in the specification. As usual, it is very difficult to steer the middle course; and if the scientific man had for years to cry in the wilderness because his pursuits did not receive the proper attention in the education of engineers, it seems now to be the turn of the practical man to warn students that there is something more to be learned besides scientific truths before they can aspire to be recognised as engineers.

It has always appeared to me that at school the mental

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powers should be principally exercised in a way to make them fit for learning, and that at the same time they should become accustomed to the careful consideration of a problem in its various aspects. Although it has been the fashion of late to deprecate the study of Latin and Greek, I am quite certain that the attack is made from quarters where the mental training which the study of these languages entails is not appreciated at its right value, nor is the enormous advantage considered which their knowledge gives in the study of modern languages. After the mental powers have been prepared in this way, it is of no great consequence whether most of the details of the school teaching are speedily forgotten or not; the essential point is that the student should have acquired a good method of learning, so as to assimilate to the best advantage the course of training he attends at college. While the teaching at school has a general character, and embraces chiefly subjects that ought to be known to all classes, at college the various professions are differentiated, and in each branch the students learn the general principles that ought to govern them in their future career.

Formerly it was possible to let the course of scientific studies embrace all that was known in any particular branch; in fact, the general principles and the interdependence of the various branches were not, and partly are not yet, properly understood. To attempt a similar course at the present time is simply impossible, and the danger that has to be avoided in our scientific colleges is the tendency to teach our profession too much in detail. Besides overwhelming the professors with work, such a course is apt to create in the students the conviction that on leaving college with a first-class certificate they know all that can possibly be known, and that anything that does not fit in with the theory of their pet professor must necessarily be condemned.

A fault into which young men are liable to fall, when they come full of honours from college, is that they consider the passing through workshops beneath their dignity, especially when they have attended for the prescribed time in the workshop of the college. They quite forget that the practical conditions that prevail in works where machinery is made for sale differ entirely from those of a laboratory, where the only aim is to give the students an opportunity of acquiring manual skill. Another class of students commences practical work with the greatest interest, and the fixed determination to introduce with all possible speed the various improvements which the difference of the practical work with which they come in contact from the teaching at college suggests to them. On all these students it cannot be impressed too much that the practical training is of quite as much importance as the scientific course at college; in fact, in most cases the conclusions of pure science have to be modified by practical considerations before a useful application of science can be produced.

For this reason it is highly desirable that the teaching at engineering colleges should be confined to general principles as far as the applications of science are concerned, but that the students should become thoroughly well acquainted with the mental tools that are used in scientific investigations, such as mathematics, the general principles of chemistry, and of the branches of natural philosophy. While the student is trained afterwards in practical work, he has time to select what special branch of the profession he wishes to devote his life to, and no doubt he will find that his college studies have to be supplemented by reading up the various technical works referring more particularly to the selected branch. If he has been able to acquire a certain knowledge of modern languages, he will find his labours lightened very materially by having a much larger range of literature to select from.

In this respect electrical engineering has been especially fortunate, for it has more than any other profession an international character, and this Institution has from the very commencement counted among its members distinguished electrical engineers of many nationalities. It is quite true that after a time the principal foreign nations formed their own electrical institutions, but the international character of the profession has been kept up by the congresses which have met from time to time with a view of regulating electrical matters of international importance. At the official congress which met last year at Chicago, an international system of units of measurement has been settled, or, rather, readjusted, for the electrical engineers have from the beginning enjoyed the immense advantage that their units of measurement have been the same in all countries. Not only has this circumstance greatly promoted the intercommunication between the various nations, but the character of the electrical units facilitates the demonstration of the interdependence of the various forms of energy, and simplifies the calculations of the engineering profession. If a proof were necessary of the utility of having the same units understood in all civilised countries, it is only necessary to observe the conditions and the tendencies that prevail in other matters of international interest.

It is chiefly owing to telegraphy that the conditions of modern life differ so essentially from the state of things before the means of quickly communicating with distant parts were at the service of the community at large. Through the ever-increasing network of telegraph wires all mankind is drawn together, and the mutual reaction of the affairs of distant nations is very well illustrated by the newspapers of all countries vying with each other to bring the latest news from all parts of our globe, and by the effect this news produces at home. Not only are industrial enterprises greatly aided by the possibility of watching their progress in distant countries as easily as it was formerly possible to follow the fortunes of works in the next county, but the distribution of the commodities of life can be regulated in such a way that an extraordinary demand in one country can be met by an extraordinary supply from another one. Under such conditions of intercommunication it is not to be wondered at that attempts have been made, and, in fact, have been to a great extent successful, for facilitating the intercourse between nations in various directions where an international agreement could do away with existing difficulties.

One of the most important international conventions is the Postal Union, into which most nations of our globe have entered, and whose influence is brought home to us every day. In another direction an effort has lately been made to make the mode of reckoning time more uniform, and the result is that Greenwich time has practically been adopted in a great many civilised countries by making the local time either the same, or differing from Greenwich by one hour or by multiples of an hour. An even more important agreement among many nations has existed now for more than a quarter of a century by their adopting the metrical system of measurement; and it is well worth while seriously to consider the effect of this concerted action on the part of foreign nations, as it forms an ever-increasing obstacle for the successful competition of English manufacturers. An ideal system of measurement should be based on units which can be reproduced at any time and at any place with mathematical precision, and you all know that the metrical system was intended to embody this desirable condition. From various causes, into which I need not enter here, the attempt has failed; even the kilogramme does not bear the relationship to the linear units which it originally was intended to have, so that the bases of the metrical system are now an arbitrary metre and an arbitrary kilogramme. All the same, its very general adoption has proved a very great convenience, and there is little doubt that the introduction of international electrical units has been accomplished with such facility because they are based on the metrical system.

When we recollect that it was a German professor who suggested the absolute system of measurement, that the British Association first established practical electrical units, that the metrical system is of French origin, and that the electrical system of measurement was elaborated by discussions between engineers and scientific men of all nations at the various congresses, we cannot wonder that a very perfect system has been the outcome, and that its general adoption in all countries has followed without discussion, although the formal recognition may not yet have been pronounced in all cases. Even in this system it has been found necessary to settle one of the units—the ohm—in an arbitrary manner, as it was recognised that for practical purposes it was better to have an arbitrary but fixed standard, than to correct the unit every time that

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an improvement in methods or in instruments admitted of determining it with greater accuracy than before. It is well worth while to reflect on the lesson which this fact conveys—viz., that, in spite of the earnest endeavours and the painstaking collaboration of most competent men, it has not been possible to follow out in practice the dictates of pure science, but that a compromise was found to be inevitable.

The conclusions to which this consideration of the influences that have shaped the course of electrical engineering leads us, may well awake in us the hope of an ever-increasing activity and of an ever-growing importance of the applications of electricity; but we must not forget that we can only succeed if we understand how to adapt our work to practical requirements without losing sight of scientific laws. For this reason nothing can further the interests of our profession more than a free and frequent interchange of ideas between the engineers, who carry out the practical applications, and the scientific men, who investigate the nature of electricity.

In the past this Institution has been the arena in which many subjects have thus been discussed to the advantage of everybody concerned; and it is the duty of all its members to contribute, either by reading papers or by criticising those submitted by others, to the development and to the ever-increasing importance of the electrical engineers.

IMPEDANCE IN AERIAL LINES AND ALTERNATE CURRENTS.

M. Hospitalier, in an article in *L'Industrie Electrique*, considers the question as indicated by the following abstract:

The increase of effective resistance in a conductor of circular section to the passage of alternate current is not so important as the inductive phenomena. The formulæ given below permit the calculation of the impedance in aerial lines, and the determination of the increase of pressure required to overcome this impedance.

Let the aerial line be formed of two parallel wires of radius r, length l, the total length of the wires being $2\,l$, at a distance d, with a self-induction L, a resistance R, the wire having a resistivity ρ, all the quantities being measured in C.G.S. units. The impedance of this line for an alternate current of pulsation ω (calling pulsation, with Prof. Fleming, $2\,\pi$ times the frequency) will be equal to

$$\sqrt{R^2 + \omega^2 L^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

and supposing $\sqrt{R^2 + \omega^2 L^2} = k\,R$,

we have a relation which defines a new physical quantity, which Mr. Kennelly calls the "factor of impedance." This, by definition, is the factor by which the electric resistance has to be multiplied to obtain the impedance or apparent resistance.

In the particular case considered with a double aerial line of parallel copper wires of circular section, we have—

$$L = 2\,l\left(\frac{1}{2} + 2\,\log_e \frac{d}{r}\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

$$R = \frac{\rho \cdot 2\,l}{s};$$

$$R^2 = \frac{4\,\rho^2\,l^2}{s^2} = \frac{4\,\rho^2\,l^2}{(\pi\,r^2)^2} = \frac{4\,\rho^2\,l^2}{\pi^2\,r^4};$$

$$k = \sqrt{\frac{R^2 + \omega^2\,L^2}{R^2}} = \sqrt{1 + \frac{\omega^2\,L^2}{R^2}};$$

which gives

$$k = \sqrt{1 + \pi^2\,r^4 \cdot \frac{\omega^2}{\rho^2}\left(2\,\log_e \frac{d}{r} + \frac{1}{2}\right)^2} \quad . \quad . \quad (3)$$

The calculation of the factor of impedance from this formula is troublesome. Mr. Kennelly has prepared tables giving k for wires from 1mm. to 10mm. diameter for distances varying from 0m. and 10m., and for frequencies of 40, 60, 80, 100, 120, and 140 periods per second values for all the frequencies obtaining in practice. Kennelly's 1893 table for frequency of 100 periods per second is here reproduced for use in calculating other frequencies and other resistances.

FACTORS OF IMPEDANCE FOR TWO PARALLEL COPPER WIRES AT 15° C.

$\frac{\omega}{2\,\pi} = \frac{1}{T} = 100$ periods per seconds. $\rho = 1688{\cdot}6$ C.G.S. units.

Distance between wires, in centimetres.	Diameter of wire ($2r$) in millimetres.					
	1	2	4	5	8	10
1	—	1·0018	1·015	1·028	1·092	1·142
2	—	1·0027	1·028	1·056	1·218	1·384
4	—	1·004	1·045	1 093	1·383	1·689
5	—	1·005	1·051	1·107	1·432	1·796
10	—	1·007	1·073	1·154	1·638	2·145
20	1·0007	1·009	1·098	1·207	1·844	2·510
50	1·0009	1·011	1·136	1·287	2·208	3·009
100	1·0011	1·014	1·169	1·353	2·373	3·394
200	1·0013	1·017	1·204	1·423	2·617	3·783
500	1·0015	1·021	1·252	1·521	2·929	4·302
1,000	1·0018	1·023	1·293	1·599	3·170	4·698
2,000	—	1·028	1·337	1·670	3·428	5·093
5,000	—	—	—	1·789	3·755	5·635

It will be seen, for instance, from (3), all other things being equal, we pass from frequency 100 to another frequency by the following process:

1. Square k.
2. Deduct 1.
3. Multiply the remainder by the square of the new frequency.
4. Divide by 10,000.
5. Add 1.
6. Extract the root, and the result gives the new factor of impedance.

Numerical Example.—Consider a double line of copper wires, 1m. apart and 1cm. diameter, traversed by an alternating current with a frequency of 120 periods per second. We find from Mr. Kennelly's table that the factor of impedance is 3·394 for a frequency of 100 periods per second. This impedance will be between three or four times that of the resistance found by means of a Wheatstone bridge.

For a frequency of 120 periods per second we shall get

1. $(3{\cdot}39)^2 = 11{\cdot}49.$
2. $11{\cdot}49 - 1 = 10{\cdot}49.$
3. $10{\cdot}49 \times 120^2 = 151{,}056.$
4. $\frac{151{,}056}{10{,}000} = 15{\cdot}1.$
5. $15{\cdot}1 + 1 = 16{\cdot}1.$
6. $\sqrt{16{\cdot}1} = 4{\cdot}01.$

Thus in passing from a frequency of 100 to one of 120, the factor of impedance is increased from 3·39 to 4·01.

If, for example, it is required to convey 10 km. ($2\,l = 20$ km.) a current of 20 amperes, the resistance of the line will be 4 ohms, and the impedance will be 16 ohms; so that in order to obtain 2,000 effective volts pressure, it is necessary to produce 2,320 at the outgoing terminals instead of 2,080, which would suffice if the line had no self-induction. It is hardly necessary to point out that the loss of energy upon the line does not correspond with the product $C^2\,R$—current squared into effective resistance; it is in this particular case $4 \times 20^2 = 1{,}600$ watts, and not the product of current squared × by impedance, which represents a quadruple loss, or 6,400 watts.

Referring to M. Hospitalier's table published in our issue of December 29, it will there be seen that the effective resistance of the conductor does not sensibly differ from the electric resistance, the self-induction being inappreciable for wires of 1cm. diameter and ordinary frequencies, but the impedance, on the contrary, is increased.

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These calculations assume electrostatic capacity negligible. If capacity has to be considered, as in the case of concentric cables, or cables in juxtaposition, the formulæ are more complex, and not yet authoritatively agreed.

ELECTRICITY IN THE PANTOMIMES.

The earliest, best, and most consistent users of electrical energy for lighting purposes have been theatrical managers. Gradually, too, there is an increasing use of this illuminant for scenic purposes, and its portable form especially lends itself to artistic effect which can be obtained in no other way. Many thousands of young and old people have visited Drury Lane and the Lyceum during the present pantomime season, and have seen the use made of electricity on the stage.

A much freer use of the illuminant is made by Mr. Oscar Barrett at the Lyceum for his beautiful pantomime, "Cinderella," than is made by Sir Augustus Harris at Drury Lane. Our artist, Mr. W. M. Bowles, has visited both theatres, and in the accompanying sketches on pp. 77, 80, and 81, has attempted to delineate the uses made of the electric light. At the Lyceum the light appears in various scenes; thus in Scene 1, the "Factories of Fairyland," two fairy glass slippers on cushions appear, each being supplied with two 2½-c.p. lamps.

The fire in Scene 4, the "Kitchen at the Baron's," is produced by a cluster of ruby-coloured lamps. The vision in the overmantel is illuminated by means of a 100-c.p. lamp, with a resistance in circuit. The resistance is used to gradually bring the lamp from a state of non-luminosity to its full incandescence and then back again.

In Scene 5, the "Fairy Boudoir," the fairy slippers, electrically lighted, are again introduced, and are supposed to be placed on Cinderella's feet. Immediately lights on Cinderella's feet spring up, giving her the appearance of wearing the glass slippers. The two huge candles in this scene are each supplied with a fully-run 100-c.p. lamp, contact with the lamps being made by floor plugs. Perhaps one of the most beautiful properties in this scene is the scent-bottle. Concealed within this are 11 25-c.p. lamps so coloured as to produce prismatic tints on the glass.

The carriage in which Cinderella goes to the ball is lighted by 52 2½-c.p. lamps, all energised by a small 30 ampere-hour lithanode battery. The current used is about 65 amperes. Between each spoke of the four wheels a lamp is placed, and all the lamps are run in parallel. Although the wheels revolve, yet the current through the lamps is never interrupted, and constant luminosity is obtained. Each wheel is protected by a cut-out, and the current is under the control of one switch.

The palace entrance and terrace in Scene 7, the "Grounds of the Palace," is decorated with a large number of electrically-lighted floral sprays, each spray representing flowers in different stages of bloom. There are 26 sprays. The largest contains 10 lamps and the smallest five lamps. In each of these electrical fittings three kinds of lamps are used. The smallest lamps are arranged at the top of the sprays, and represent the flower buds. Lower down a larger-sized lamp is used, and these give the appearance of a flower just opening. Then lower down the flowers appear to be in fuller bloom, and at the base of the spray the lamps represent the full-blown flower. All the lamps are covered with a wire frame, on which is placed silk to give the desired natural colour of the flower.

Each floral fitting is mounted in a conical metal shoe which fits a metal socket which is firmly secured to the scenery. The electricity is led into the sprays by flexible wires and suitable wall plugs. All the floral fittings are detachable, and they have to be fixed and removed each time the scene is set. This is sharp work, as only 10 minutes is allowed for setting up the scene and about seven minutes for removing it.

The base of the structure forming the "palace" is divided into nine sections, and each of these has been connected up electrically by means of flexible wires and stout wall plugs. The current from the supply company's mains is carried up on to the stage, and is controlled by a switch and fuse on each lead. The wires leaving the switches are carried under the stage and terminate in a fireproof junction-box, which opens up on to the stage floor. Cables capable of carrying 100 amperes from the stage box and a junction-box are fixed on the back of the main part of the scenery. About 200 lamps are used, each taking about 0·3 ampere and 100 volts to fully incandesce them. The total current used is about 65 amperes, and the duration of light is about 15 minutes.

At the termination of this scene the lights are turned off and the electrically-illuminated slipper is discovered on the stage. The slipper used here is fitted with three 2½-c.p. lamps.

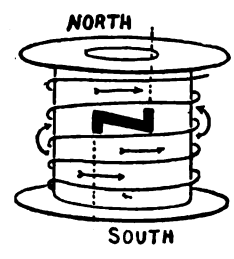
The whole of the electrical properties used on the stage in this pantomime were designed and made by the Lithanode Company and were installed by them, and are being electrically worked and maintained for Mr. Oscar Barrett by the company.

Turning from the Lyceum to Drury Lane, the recognised centre of English pantomime—where for many years Sir Augustus Harris has provided entertainments unsurpassed for spectacular effect, and where this year he has not fallen short of anything that has ever gone before—we find a mass of glitter and colour which has artistic beauties appealing to all playgoers. Sir Augustus Harris, however, has not largely employed electricity, but where he has done so it heightens the brilliancy of the scene. Perhaps one of the prettiest effects is obtained in the fish ballet, wherein troupe after troupe of imitation fish pass before the sightseers. In those members of the *corps de ballet* representing mackerel small four-volt lamps are used in the head-dress, as shown in the picture. These lamps are actuated by portable lithanode batteries, and thus a very brilliant effect is obtained. The portable batteries are two-cell batteries to give an ampere-hour. At the commencement of what we may term the pantomime proper, Mr. Harry Payne and his colleagues are introduced by Miss Kingston as "the Spirit of the Pantomime," and this spirit has the star upon her forehead, or rather upon her head-dress, in the shape of an incandescent lamp. Considerable use also is made of electricity in the transformation scene.

But perhaps the great attraction in this year's pantomime at Drury Lane is in the "English History Procession," which concludes with one of the most brilliant scenes that have ever appeared in the theatre. This procession, too, has a great educational value, for youngsters will undoubtedly recollect the variations in dress that occur in the various periods of our history far better than they will by any amount of reading, plain or illustrated.

POLARITY OF ELECTROMAGNETS.

Mr. Lopez, in the columns of our American contemporary the *Electrical Review*, gives yet another rule for finding the north or south poles of an electromagnet. He uses the letter Z as an indicator, and says: "Imagine the line which connects the parallel lines of a letter Z to be a little more



perpendicular than is usually written. Apply this letter to the electromagnet so that the connecting line of the Z shall lie in the same direction as the coil is wound, looking in the direction in which the current is flowing. The upper portion will point to the north pole and the lower to the south pole." The accompanying sketch shows the principle of the rule.

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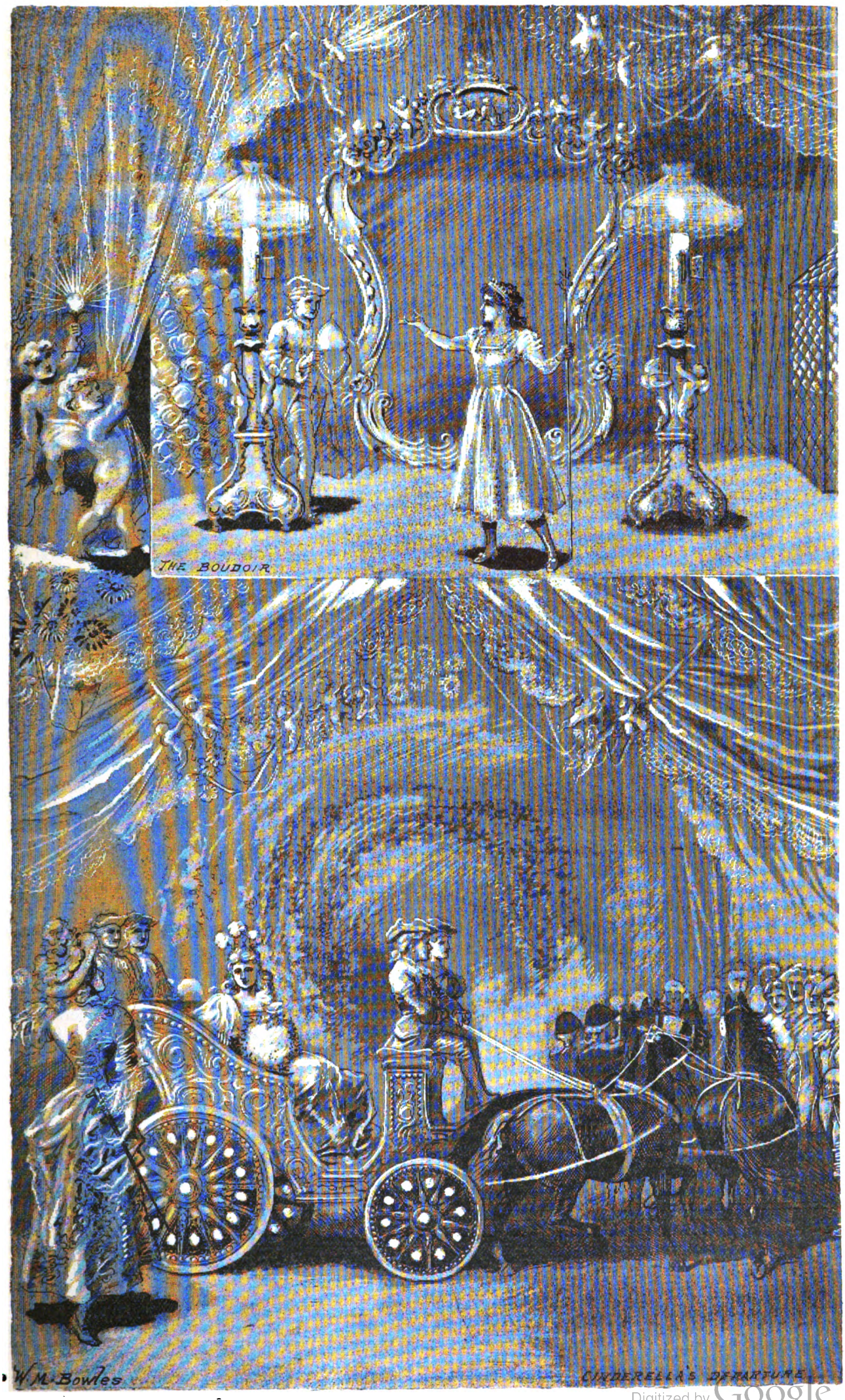

SCENES IN THE LYCEUM PANTOMIME.

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THE

ELECTRICAL ENGINEER.

Published every Friday.

Price Threepence; Post Free, Threepence Halfpenny.

Editorial and Publishing Offices:

39-140, SALISBURY COURT, FLEET STREET, LONDON, E.C.

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TO CORRESPONDENTS.

All Rights Reserved. *Secretaries and Managers of Companies are invited to furnish notice of Meetings, Issue of New Shares, Installations, Contracts, and any information connected with Electrical Engineering which may be interesting to our readers. Inventors are informed that any account of their inventions submitted to us will receive our best consideration.*

All communications intended for the Editor should be addressed C. H. W. BIGGS, *139-140, Salisbury Court, Fleet Street, London, E.C. Anonymous communications will not be noticed.*

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A NEW DANGER.

The daily papers have lately given prominence to letters commenting on this new danger, which is nothing more nor less than the blowing up of manhole covers in electrical distributing systems. We have referred to the topic before, but the companies do not seem to adopt the obvious means of remedying the trouble. It is of the first importance to recognise that there are three factors contributing to each explosion: first, we have gas leakage; secondly, a collecting chamber for an explosive mixture; and thirdly, a spark to cause the explosion of the mixture. As regards the first, we know pretty well that the soil around all gas mains and pipes is saturated with leakage gas, and we know also that if the gas is able to collect in cavities and mix with air an explosive mixture is formed. Further, we know that the electric light cable connections are made in the manholes, and that unless we can get absolute contact at the connection there may—nay, there must be sparking. No matter how carefully connections are made, there will now and again be arcing, and the spark from the arcing will explode the gaseous mixture. The obvious remedies are, in the first place, to design the subways and manholes so as to have no collection of gas. That means ventilation, for unless the manhole is airtight the lighter gas, instead of collecting, will dissipate harmlessly in the air. We venture to affirm that many manholes are airtight, and with the slightest leakage of gas into them the moment comes when the mixture is explosive. If, however, the joints and connections are perfect, the mixture is harmless; but joints and connections are not always perfect. Thus an imperfect contact in the manhole is one of the causes of the trouble. Electrical engineers know that this gas leakage will prove troublesome, and as the gas companies will certainly not amend the ways that have been tolerated for years, it behoves the electric supply companies to adapt their designs so that the dissipation of the gas is assured. It is perfectly evidently to all who study town life that the possible uprising of a manhole cover at any moment cannot be permitted, and as the remedy is so simple the danger will not be tolerated. In some cases, the spark which causes the explosion is in no way connected with the supply mains; but it must be regretfully admitted that in certain cases it must have arisen in the manner we have indicated. If it were possible in every case to ensure perfect connections, that would be an effective remedy; but in the present state of practice it would be dangerous to recommend it in preference to ventilation. The latter would not only be equally effective, but would also have the merit of greater simplicity. There are many causes which contribute to the giving way of a joint or, at least, which render its insulation imperfect, but it is difficult to see how any properly designed system of ventilation could be so seriously interfered with as to permit of the collection of gas and air under pressure. It will be seen that we do not contemplate sparking through any other cause than bad connections; but there are other causes, which, however, mostly occur through carelessness or

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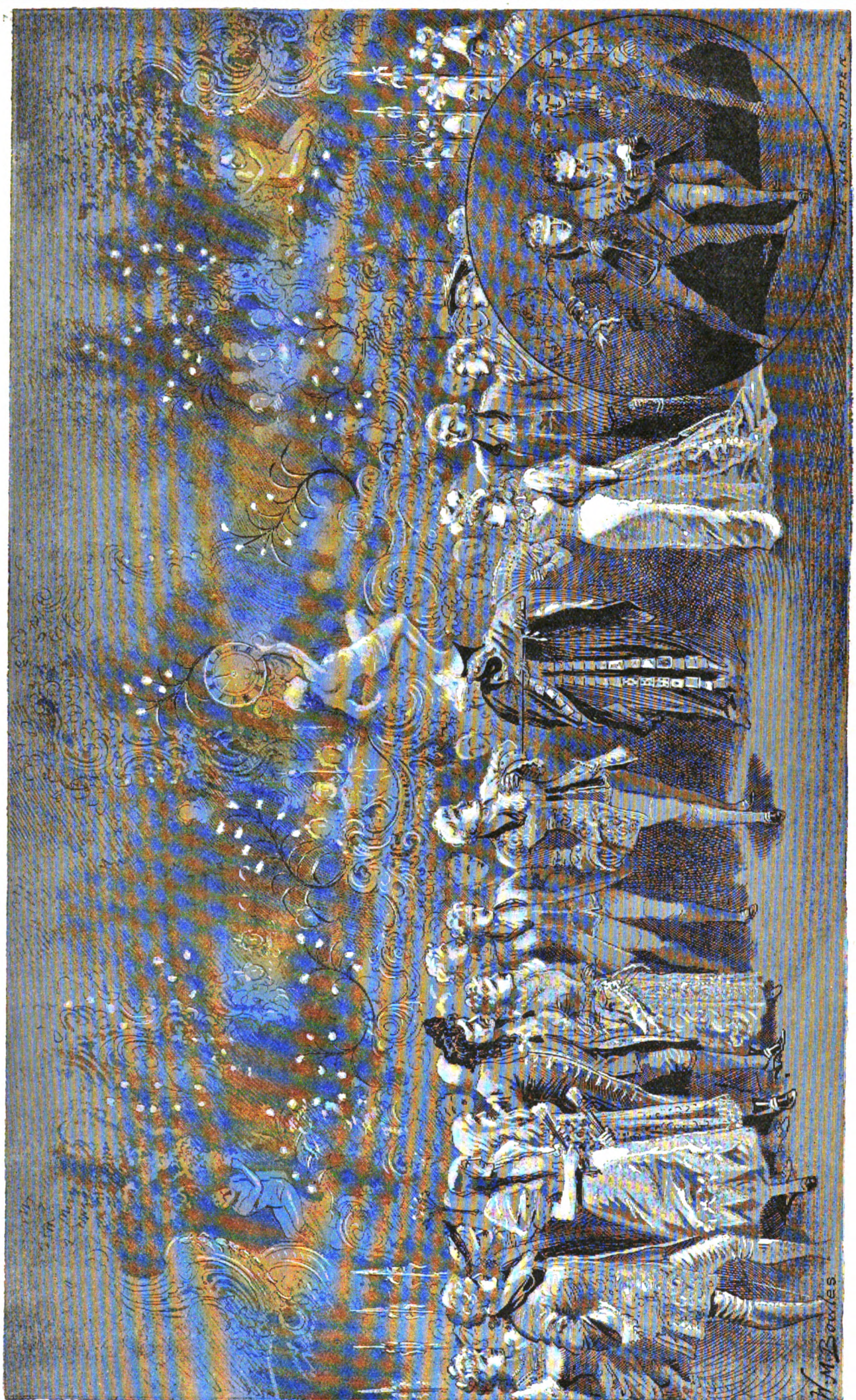

SCENE IN THE GROUNDS OF THE PALACE IN THE LYCEUM PANTOMIME.

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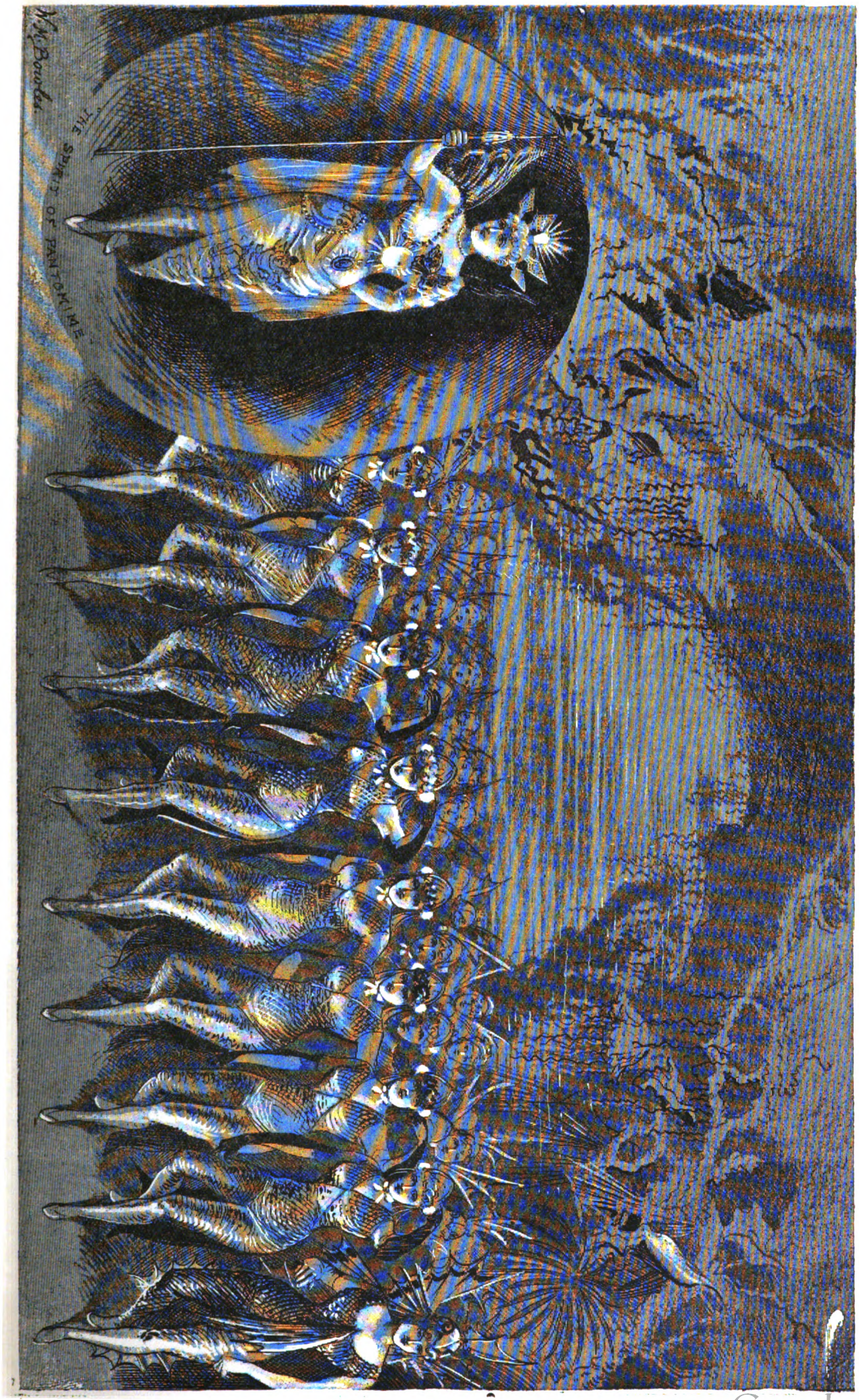

THE MACKEREL TROOP IN THE FISH BALLET AT DRURY LANE THEATRE.

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laziness of workmen. Loose metallic contacts do not place themselves of their own accord in manholes or across cables, and in such cases no amount of care will guard against wilful attempts at damage. Strict supervision may partially prevent these contacts, but it is possible that the cure will be through the criminal law rather than from any other source.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

SHUNTS.

SIR,—I had written a somewhat long letter on this subject, but forbear to send it; but a few words are necessary to bring this discussion to a conclusion. So far my contention is allowed—viz., that the text-books do not explain the phenomena of shunts. Each correspondent agrees in that, though they may not agree together—and no text-book authority has been bold enough to defend his book. That is all right; perhaps in future editions authors will pay a little attention to the matter, and not waste our time, money, and temper in a vain endeavour to believe what is not correct. I thank, heartily thank Mr. Sinnott for his letter, which confirms my suspicion as to the text-books. Now a word to Mr. Yellowplush. He attempts to flatter me by placing me on a pedestal upon which he looks and runs away. According to my lights (electric), you, Sir, have merely stated that, with pressure constant, branch circuits or shunts do not interfere with each other, and thus there is no division of the original current. Mr. Yellowplush is so evidently ignorant of the whole subject that he has not yet attempted to justify his remarks, but prefers to suggest that you and I are one, and gives this, I presume, as an excuse for not explaining what the real effect of a shunt is. I have asked for a text-book which really explains, but Mr. Yellowplush has not favoured me with its title yet. I asked, does a shunt divert; and if so, what? Mr. Y. is silent on the subject. He is, however, turning out to be real nice in giving me a high position in journalism, but having ere now been identified as "G. A. S.," I am not so proud of the position he affects to suggest I fill as I might otherwise be. An artist of my acquaintance hinted that a mixture with sky-blue might better show his real colour, but my education is defective in colour-mixture. So I must leave some more learned brother to say what the result would be.—Yours, etc.,

H. L.

HIGH-SPEED ELECTRIC RAILWAYS.

SIR,—With reference to Mr. Wolff's letter in your last issue under the above title, I hasten to thank him for his endeavour to explain the disparity between the air resistance values mentioned in my article, and at the same time to express my fear that his explanation does not quite "fill the bill." When writing, I purposely made the statement conditional, "If this—*i.e.*, the air resistance—be considered to act wholly in a direction parallel to the line of travel, with close-coupled cars," etc.

I would not like to affirm absolutely that only the head resistance need be taken into account, even when the train has specially-shaped ends, is built without projections, and is coupled up so closely as to offer a continuous surface on the sides and intermediate ends; but I certainly think Mr. Wolff assumes too much when he says he "*knows* that skin friction forms a large part of the resistance, and *varies with the square of the velocity*."

So far the latest experiments tend to show that even the head resistance varies with the first and not the second power of the velocity, and I do not think the skin friction would follow any different law. Then the amount of skin friction in the case discussed is extremely small—so small as to create a disparity in the other direction.

If the air resistance is assumed to act equally over the whole area of train—say 8,000 square feet—then its value hardly exceeds $\frac{3}{8}$lb. per square foot; whilst if we take 15lb. per square foot for the head resistance, then the side resistance representing the skin friction is only $\frac{1}{5}$lb. per square foot.

This may be a fair average value, but I very much doubt whether the effect of this side resistance is at all as great as Mr. Wolff supposes. It may in some cases be to no small extent balanced by the air eddies at the end of the train.

Of course, on ordinary steam railroads at usual speeds, side winds cause a much greater demand on the coal-pile than those dead ahead; but this is not by any means solely because of the extra air resistance. The tilting over of a train by wind pressure throws more weight upon one side, and increases the track resistance enormously, with a corresponding call for more energy from the locomotive.

With a train properly designed and constructed I doubt very much whether the skin friction, *per se* (especially at high speeds), requires the expenditure of any serious amount of energy; certainly not to the same extent as the head resistance. As I stated, however, in my article, the absolute lack of reliable data upon this and kindred points, makes it impossible to dogmatise in any way. One can only assume—perhaps incorrectly.—Yours, etc.,

FRANK B. LEA.

THE TENDENCY OF BUSINESS.

SIR,—It appears from your leader of last week that you regard my remarks with reference to sub-companies as reprehending to some extent the character of the business done in the past in supply-station work. My remarks should not have conveyed this meaning, as I merely called attention to the fact that the larger manufacturing concerns had a considerable holding in sub-companies, and that the taking of shares for work done had greatly quickened the development of the electrical industry towards its final stage of evolution. The result is that the firms which assisted in the promotion of companies in the early stages now get the bulk of supply work, while those which could not command capital have gradually settled down to work in other branches. That progress would have been greatly delayed if business had not been thus *made*, is precisely what by inference I pointed out; and it by no means follows that I regard sub-companies as an evil, or that I regret the circumstance that the shareholders in electric manufacturing enterprises become incidentally shareholders in supply companies. This factor has had a great directional influence on the industry, and that is all I wished to point out.—Yours, etc.,

W. B. ESSON.

THE EARL'S COURT EXHIBITION.

SIR,—We observe in your business notices for 1893 you state that the Brush Company supplied the whole of the electrical plant at the Earl's Court Exhibition. As this statement would lead your readers to suppose that the arc lamps were included in the plant, we beg to say that both inside the building and in the gardens the standard "Brockie-Pell" arc lamp was used throughout.—Yours, etc.,

JOHNSON AND PHILLIPS.

14, Union-court, Old Broad-street, E.C., Jan. 15, 1894.

THE TESLA ELECTRICAL OSCILLATOR.*

In the lecture delivered before the Chicago Electrical Congress, Mr. Nikola Tesla first drew attention to the method and means which he had devised for the continuous production of alternating currents of constant period, and in which all rotating parts are avoided by the employment of his oscillating engine directly to the movement of the generating coil in the magnetic field.

The main reason why no engine heretofore has been capable of producing results of this nature is that it has been customary to connect with the reciprocating parts a heavy flywheel, or some equivalent rotary system of relatively very great inertia, or in other cases where no rotary

* From an advance proof of the *Electrical Engineer* (New York).

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system was employed, as in certain reciprocating engines or tools, no regard has been paid to the obtainment of the conditions essential to the end which Mr. Tesla had in view.

In applying the Tesla oscillator for the generation of currents of constant period, certain conditions are encountered which must be taken into consideration in order to satisfactorily secure the desired result. When a conductor is moved in a magnetic field and a current caused to circulate therein, the electromagnetic reaction between it and the field might disturb the mechanical oscillation to such an extent as to throw it out of isochronism. This, for instance, might occur when the electromagnetic reaction is very great in comparison to the power of the engine, and there is a retardation of the current, so that the electromagnetic reaction might have an effect similar to that which would result from a variation of the tension of the spring; but if the circuit of the generator be adjusted so that the phases of the E.M.F. and current coincide in time—that is to say, when the current is not retarded—then the generator driven by the engine acts merely as a fractional resistance, and will not, as a rule, alter the period of the mechanical vibration, although it may its amplitude. This condition may be readily secured by properly proportioning the self-induction and capacity of the circuit, including the generator.

Mr. Tesla has, however, observed the further fact in connection with the use of such engines as a means for running a generator, that it is advantageous that the period of the engine and the natural period of electrical vibration of the generator should be the same, as in such case the best conditions for electrical resonance are established, and the possibility of disturbing the period of mechanical vibrations is reduced to a minimum. Mr. Tesla has found that even if the theoretical conditions necessary for maintaining a constant period in the engine itself are not exactly maintained, still the engine and generator combined will vibrate at a constant period. For example, if instead of using in the engine an independent cylinder and plunger, as an air spring of practically constant rigidity, the piston may impinge upon air cushions at the ends of its own cylinder. Although the rigidity of such cushions or springs might be considerably affected and varied by the variations of pressure within the cylinder, still by combining with such an engine a generator which has a period of its own, approximately that of the engine, constant vibration may be maintained even through a considerable range of varying pressure, owing to the controlling action of the electromagnetic system.

Indeed, Mr. Tesla has even found that under certain conditions the influence of the electromagnetic system may be made so great as to entirely control the period of the mechanical vibration within wide limits of varying pressure. This is likely to occur in those instances where the power of the engine, while fully capable of maintaining a vibration once started, is not sufficient to change its rate.

In our issue of November 8, 1893, we gave the details of construction of the Tesla oscillator, and a patent just issued to Mr. Tesla now enables us to supplement our previous descriptions with those of other types employed by him in this work. The accompanying engraving, Fig. 1, is a sectional view of an oscillator fulfilling the conditions laid down above.

Referring to Fig. 1, A is the main cylinder in which works a piston, B. Inlet ports, C C, pass through the sides of the cylinder opening at the middle and on opposite sides. Exhaust ports, D D, extend through the walls of the cylinder, and are formed with branches that open into the interior of the cylinder on each side of the inlet ports and on opposite sides of the cylinder. The piston, B, has two circumferential grooves, E F, which communicate through openings, G, in the piston with the cylinder on opposite sides of the piston respectively. The particular construction of the cylinder, the piston, and the ports controlling it may be very much varied, and is not in itself material, except that in the special case under consideration it is desirable that all the ports, and more especially the exhaust ports, should be made very much larger than is usually the case, so that no force due to the action of the steam or compressed air will tend to retard or affect the return of the piston in either direction. The piston, B, is secured to a piston-rod, H, which works in suitable stuffing-boxes in the heads of the cylinder A. This rod is prolonged on one side and extends through bearings, V, in a cylinder, I, mounted in line with the first, and within which is a disc or plunger, J, carried by the rod, H. The cylinder, I, is without parts of any kind, and is airtight except as a small leakage may occur through the bearings, V, which experience has shown need not be fitted with any very considerable accuracy. The cylinder I is surrounded by a jacket, K, which leaves an open space or chamber around it. The bearings, V, in the cylinder, extend through the jacket to the outside air, and the chamber between the cylinder and jacket is made steam or air tight by a suitable packing. The main supply pipe, L, for steam or compressed air leads into this chamber, and the two pipes that lead to cylinder A run from this chamber, oil-cups, M, being conveniently arranged to deliver oil into the pipes for lubricating the piston.

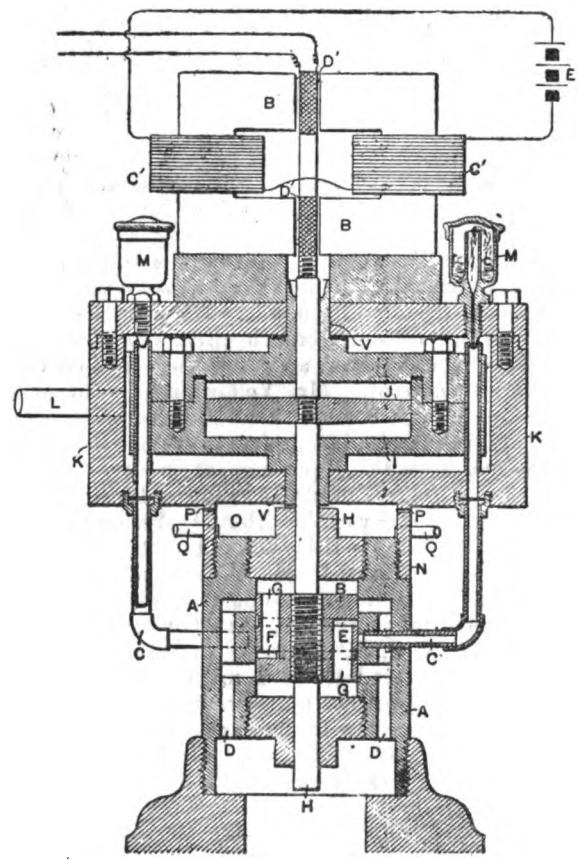

FIG. 1.

In the particular form of engine shown, the jacket, K, which contains the cylinder I is provided with a flange, N, by which it is screwed to the end of the cylinder A. A small chamber, O, is thus formed which has air-vents, P, in its sides, and drip pipes, Q, leading out from it through which the oil which collects in it is carried off. In the position of the parts shown, or when the piston is at the middle point of its stroke, the plunger, J, is at the centre of the cylinder I, and the air on both sides of the same is at the normal pressure of the outside atmosphere. If a source of steam or compressed air be then connected to the inlet ports, C C, of the cylinder A, and a movement be imparted to the piston as by a sudden blow, the latter begins to reciprocate in the well-known way. The movements of the piston compress and rarefy the air in the cylinder I at opposite ends, alternately. A forward stroke compresses the air ahead of the plunger, J, which acts as a spring to return it; similarly, on the back stroke the air is compressed on the opposite side of the plunger, J, and tends to drive it forward. The compressions of the air in the cylinder, I, and the consequent loss of energy due mainly to the imperfect elasticity of the air, gave rise to a very considerable amount of heat. This heat is utilised by conducting the steam or com-

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pressed air to the engine cylinder through the chamber formed by the jacket surrounding the air-spring cylinder, the heat thus taken up and used to raise the temperature of the steam or air acting upon the piston is availed of to increase the efficiency of the engine.

In any given engine of this kind the normal pressure will produce a stroke of determined length, and this will be increased or diminished according to the increase of pressure above, or the reduction of pressure below, the normal. In constructing the apparatus proper allowance is made for a variation in the length of stroke by giving to the confining cylinder, I, of the air spring properly determined dimensions. The greater the pressure upon the piston, the higher will be the degree of compression of the air spring, and the consequent counteracting force upon the plunger. The rate or period of reciprocation of the piston, however, is mainly determined by the rigidity of the air spring and the inertia of the moving system, and any period of oscillation within very wide limits may be secured by properly portioning these factors, as by varying

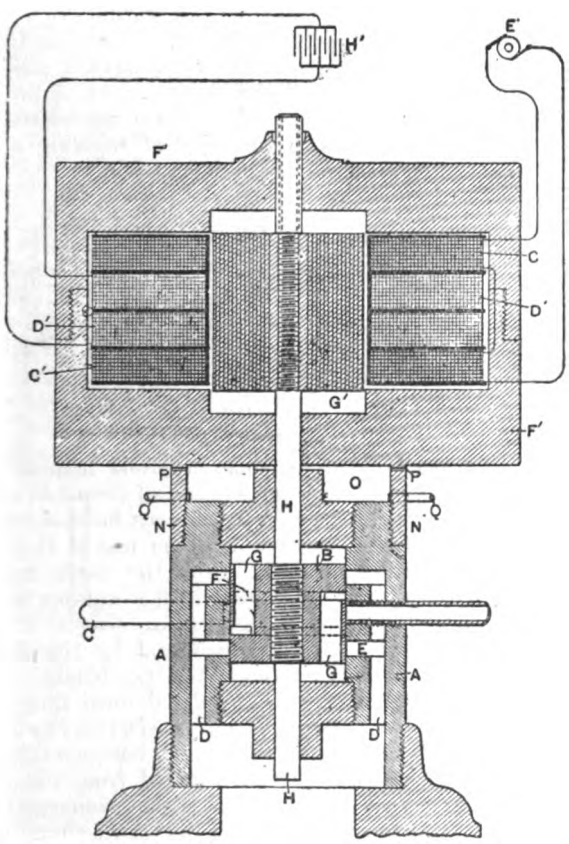

FIG. 2.

the dimensions of the air-chamber, which is equivalent to varying the rigidity of the spring, or by adjusting the weight of the moving parts. These conditions are all readily determinable, and an engine constructed as above described maintains a perfectly uniform period through very wide limits of pressure. The pressure of the air confined in the cylinder when the plunger, I, is in its central position will always be practically that of the surrounding atmosphere, for while the cylinder is so constructed as not to permit such sudden escape of air as to sensibly impair or modify the action of the air spring there will still be a slow leakage of air into or out of it around the piston-rod according to the pressure therein, so that the pressure of air on opposite sides of the plunger will always tend to remain at that of the outside atmosphere. To the piston-rod, H, is secured a coil, D', which, by the movements of the piston, is oscillated in the magnetic field produced by two magnets, B' B', which may be permanent magnets or energised by coils, C' C', connected with a source of continuous current, E'. The movement of the coil D' across the lines of force established by the magnets gives rise to alternating currents in the coil. These currents, if the period of mechanical oscillation be constant, will be of constant period. In the case under consideration it is assumed as a necessary condition that the inertia of the movable element of the generator and the electro magnetic reaction which it exerts will not be of such a character as to materially disturb the action of the engine.

Fig. 2 is an example of a combination in which the engine is not of itself capable of determining entirely the period of oscillation, but in which the generator contributes to this end. In this figure the engine is the same as that shown in Fig. 1. The exterior air spring is, however, omitted, and the air-spaces at the ends of the cylinder, A, relied on for accomplishing the same purpose. As the pressure in these spaces is liable to variations from variations in the steam or gas used in impelling the piston they might affect the period of oscillations, and the conditions are not as stable and certain as in the case of an engine constructed as in Fig. 1. But if the natural period of vibration of the elastic system be made to approximately accord with the average period of the engine, such tendencies to variation are very largely overcome, and the engine will preserve its period even through a considerable range of variation of pressure. The generator in this case is composed of a magnetic casing, F', in which a laminated core, G', secured to the piston-rod, H, is caused to vibrate. Surrounding the plunger are two exciting coils, C' C', and one or more induced coils, D' D'. The coils C' C' are connected with a generator of continuous currents, E', and are wound to produce consequent poles in the core, G'. Any movement of the latter will therefore shift the lines of force through coils D' D', and produce currents therein. In the circuit of coils D' is shown a condenser, H'. By the use of a proper condenser the self-induction of this circuit may be neutralised. Such a circuit will have a certain natural period of vibration, and, as this depends upon the capacity and self-induction, the period may be varied to approximately accord with the period of the engine.

In case the power of the engine be comparatively small, as when the pressure is applied through a very small fraction of the total stroke, the electrical vibration will tend to control the period, and it is clear that if the character of such vibration be not very widely different from the average period of vibration of the engine under ordinary working conditions, that such control may be entirely adequate to produce the desired results.

ELECTRIC RAILWAY MOTORS: THEIR CONSTRUCTION AND OPERATION.*

BY NELSON W. PERRY.

Some years ago I became acquainted, as a boarder, with a bright young man who introduced himself to me as an electrician. It happened we were placed at the same table, and as he was of an affable disposition we soon became very well acquainted. Whenever the subject of electricity came up, he was accustomed to speak in such a way as to impress all his hearers with the idea that he was an authority on all such subjects whose opinions were not to be questioned, and as he was generally correct in his statements, I also became somewhat impressed with his knowledge, and would often ask questions—sometimes for information and sometimes to see how nearly his opinions coincided with my own.

I found that he had been sent out by the then leading company engaged in electrical railway construction, and his business in that city (a Western one) was the construction of its first electric railway. We soon became quite good friends, and when the power-house was nearing completion I was a privileged character within its walls, for visitors were rigidly excluded as a rule; and, later, when the first tests of the operation of the road were made, I was one of the fortunate few invited guests.

The first car over the line started out from the barns at 10 o'clock at night, and carried as passengers, besides myself and the gentleman referred to, but three others—all officials of the road. Everything went smoothly until the further terminus—about three miles distant—was reached, when something gave way and we were stalled.

* From the *Street Railway Gazette*.

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I must add here that my friend had not yet discovered that I was myself an electrician. I had had no other object in concealing the fact than that as I had not been asked my business, it had never been necessary for me to declare it, and I felt that he would talk with me more freely if he did not know it. He knew that I was an engineer, however, and he attributed my ability to solve certain questions which arose to that fact—to that combined with what he took to be a smattering of electricity which he supposed I had acquired in some way or other.

As a matter of fact, however, I considered myself a full-fledged electrical engineer, and was as electrical engineers went in those days, for besides having had a pretty thorough training on the purely theoretical side of electricity, I had worked in two of the largest shops in the country in all the departments of electrical manufacture. I had wound armatures and fields, and assisted in making and dressing down all the other parts of machines, both large and small, had assembled these various parts, connected them up, soldered the connections, and finally tested the completed machines. I had also assisted in installing one road myself, and had inspected every road but one that was at that time in operation in the country, so that I was pretty familiar with electric railway construction as then developed. I knew that my friend's experience had not been nearly as wide as my own, and I was glad to be with him on the occasion of the opening test of this, which I suspected was the first road over whose construction he had been completely in charge.

Well, as I say, something had happened, which was only really discovered when the attempt was made to run the car back. There was a considerable grade at starting, and this the car failed to ascend. We backed down to the level and tried it again. The car worked all right until the grade was reached, when she stopped again. This was repeated a number of times, and always with the same result. My own experience made me suspect at once the true trouble, but it would not do for me to suggest. My friend had been playing the *rôle* of a great authority on electric railroad matters for the special benefit of his invited guests on the car. He was in very high feather, and not without reason, that night, because the work of his hands was finished, and now he was showing his admiring guests how immeasurably better it worked than even his own anticipations had led him to hope.

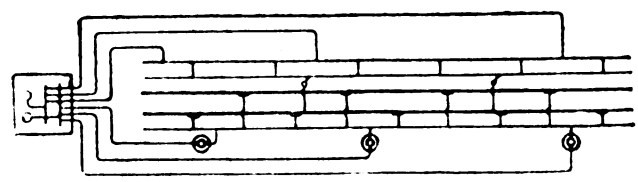
For me to have suggested the cause would been considered a piece of impertinence of the highest order, not only by him, but by the other guests, who looked upon my friend as a wonderful man; so I kept quiet.

My friend was a man of great self-confidence and equal to the emergency. In reply to enquiring glances, he said it was due to "something or other"—using a term not down either in Webster's or Houston's dictionaries—that it was a very trivial matter and could easily be fixed; he would back down to the level again and fix it. He did so—that is, he backed down—and, after making an examination, said: "Yes, that's it, just as I thought; the 'something or other' was just what caused the trouble," and he straightway proceeded to correct the thing. In the meantime I had had an opportunity of verifying my suspicions, but, of course, kept my counsel. When all was declared ready we entered the car again, and my friend, who really had done nothing, as far as I had been able to see—he certainly hadn't touched the root of the trouble—turning on the current to the last notch, said, "Now we go," and we did, until we had gotten even a little way beyond the point on the grade where we had always stalled before, and then we stalled again. We had gained a few feet over previous attempts simply because we had gained a little more momentum on the level. I think my friend understood this as well as I, but he pointed to the small gain with apparent pride, and with unblushing assurance stated that that proved that he knew he was right in locating the trouble, and that now he would run back and fix the thing for good. We went back, and he got under the car again. I watched him closely this time, and, after doing absolutely nothing more than fumble around a little, he came out and announced that "Now I've fixed her for good, and I'll show you how we can mount that grade."

(To be continued.)

VAIL'S SYSTEM OF DISTRIBUTION FOR ELECTRIC RAILWAYS.

Many efforts have been made to increase the efficiency of a system of distribution in which the rails form part or all of the return circuit. The principal defects of such systems are its interference with grounded telephone circuits, its damaging effects on gas and water pipes, and often its high resistance, which may cause serious and undesirable fall of potential on parts of the line removed from the source of supply. To avoid the difficulties, Mr. J. H. Vail has devised the arrangement of circuits shown in the accompanying illustration. The positive and negative terminals of the generating plant are connected in the usual manner to the 'bus bars at the station. A continuous main conductor extends along the line, either carried upon poles or placed underground, and this is connected at intervals by branch conductors with the trolley line. Extending from the positive 'bus bar in the central station a suitable number of conductors are carried to different distances from the station where they are connected to the main conductor. These conductors are each of such size and capacity as to have a predetermined drop in potential, and the points at which they are connected with the main conductor are mathematically determined in advance with the object of securing a constant potential on all parts of the main conductor.



Vail's System of Distribution.

The rails are bonded in some suitable manner with metallic connections so as to make the rail circuit as nearly complete as possible. Another continuous main conductor for the return circuit is carried along the line of the road, and this is carefully insulated from the earth by supporting it upon poles or by placing it in a suitable insulating underground conduit. This return circuit main is connected at intervals with the rails, and for the sake of convenience this is made through the rail bonds. These branch connecting lines are also insulated until they reach their connections with the rails. If preferred, the return circuit main may be placed underground between the rails, but in this case, as before, it is insulated from the earth. The negative 'bus bar at the station is then connected by a suitable number of conductors with the return circuit main, these extending to different distances from the station, and the points of contact being so calculated in advance that each will have the same potential. By this means the difference of potential between the terminal of any car motor remains practically constant, as it travels along the line and its distances from the source of power varies.

Instead of connecting a feeder to the main line conductor at a single point, a number of connections by different wires are made within, say, the space of 100ft., so that while, electrically considered, the connections are all at a single point, there are a number of independent connections, the breaking of any one or more of which will not interrupt the circuit.—*Street Railway Gazette.*

Magnetised Side-Arms.—It is reported that bayonets belonging to marines on board her Majesty's ships have in certain cases become highly magnetised through contact with, or close proximity to, dynamos, or from other causes, the result being that compasses have become affected by sentries passing near them when wearing these side-arms. In future sentries are not to wear side-arms when on duty in the dynamo flats, and this is expected to overcome the difficulty.

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THEORY OF HYSTERESIS.

BY CHAS. A. PERKINS.

The energy absorbed by a cubic centimetre of iron when its magnetism is reversed is equal to the area of a curve whose co-ordinates are H and I. No doubt many persons are constantly making use of this fact without understanding why it is true. Even in Fleming's work on the "Alternate-Current Transformer" (vol. i., p. 65) the reader is referred to a somewhat abstruse paragraph in Maxwell's treatise for the proof.

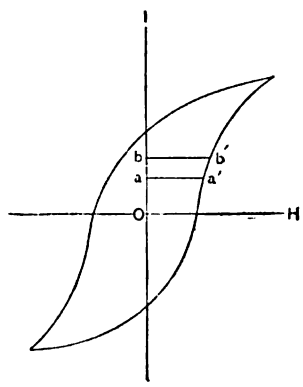
The following explanation will, however, serve to make the matter plain to anyone who understands the definitions of magnetic quantities and the principles of work and energy.

A magnetic pole of strength m when in a field of strength H is acted upon by a force m H. If it is moved a distance l in the direction of the magnetic force, the work done is $m\,l$ H. (This is the work done by the pole; but we shall pay no attention to the sign to be attached, as we are calculating only the amount of the work.)

Now let us conceive of a magnet whose length can be changed (as if it were made of indiarubber).

Let one pole stand still and the other be moved by stretching the magnet from a length l_1 to a length l_2. The work done by the magnetic force will be H m $(l_2 - l_1)$ or H $(m\,l_2 - m\,l_1)$. Now $m\,l$ is the magnetic moment of the magnet, and the intensity of magnetisation, I, is $\frac{m\,l}{\text{volume}}$.

If for convenience we take a unit volume (one cubic centimetre), then we may write $I_1 = m\,l_1$ and $I_2 = m\,l_2$ and H $(I_2 - I_1)$ is the work required to change the intensity of magnetisation from I_1 to I_2. Although we supposed this change to be made by stretching the magnet, it makes no difference how it is done if the final result is the same, and H $(I_2 - I_1)$ still represents the work required, whatever be the process of changing the value of I.



Now, in the diagram let O a represent I_1 and O b_1 I_2, then the area $a\,b\,b'\,a'$ is the value of H $(I_2 - I_1)$, and therefore represents the work required to change the magnetisation from I_1 to I_2. The whole area of the curve is made up of such areas, and therefore represents the energy necessary to perform the process indicated by the curve—viz., to magnetise the iron, demagnetise it, reverse its magnetism and again bring it back to the original condition.

The process of building up such a curve from small slices is familiar to all those who understand the principle of the indicator diagram.—*Electrical World.*

ELECTRICITY IN 1876 AND IN 1893.

BY ELIHU THOMSON.

Over a hundred years ago Tiberius Cavallo wrote in his introduction to "A Complete Treatise on Electricity" as follows: "Discoveries crowded upon discoveries, improvements upon improvements, and the science ever since that time went on with so rapid a course and is now spreading so amazingly fast, that it seems as if the subject would be soon exhausted, and electricians arrive at an end of their researches; but, however, the *ne plus ultra* is, in all probability, as yet at a great distance, and the young electrician has a vast field before him highly deserving his attention, and promising further discoveries perhaps equally or more important than those already made."

This was before the voltaic battery became known, before Davy experimented with it and produced the electric arc between carbon points, before metals were deposited in electrolysis, before the effects of electric currents on magnetism was discovered, before anything was known of the extensive fields of electromagnetic and magneto-electric induction, before the telegraph, the telephone, the electric light, the electric motor, the electric railway, the art of electric metal-working, and indeed before everything which now marks electrical science as of such great importance in our time.

I have quoted the passage above as aptly expressing a thought which has, doubtless, in these later years arisen in many minds. It might well have been written in the present year of the World's Columbian Exposition in view of the exemplification there made of the great progress in electrical arts during the period since the Centennial, 17 years ago. No similar period in the world's history has in any art shown so rapid development, so extensive and refined scientific study and experiment, so active invention, so varied application, such care and perfection in manufacture, as has taken place in the electrical field within the period mentioned.

It can be truly said that as a department of applied science and engineering, electricity has taken an important place only within the past 10 or 12 years. I do not forget that before the Centennial we had the telegraphic engineer, with his knowledge of batteries, lines, relays, sounders, etc.—a sufficient equipment for his work which was then the most important electrical application. I do not neglect the cable engineer, with his more refined and delicate methods, due to the somewhat different conditions required to be met with in the construction and operation of submarine lines. Electro-metallurgy, including electroplating and electrotyping, had already become of great utility when the Centennial year opened. But 17 years ago there were no dynamos in regular operation for electric lighting in the country, although a few machines of the Gramme and Alliance types were used abroad. Special forms of dynamo machines had been designed for electro-metallurgy, and a number of them were in use, but installed only a short time prior to 1876. Small magneto machines had been employed for a number of years previously as substitutes for primary batteries in exploding fuses for blasting and torpedo service. Electric motors, hardly worthy of the name, were here and there operated at great cost from primary batteries, but they were of insignificant power, and resembled the old designs which figured so largely in catalogues and collections of philosophical apparatus—instructive enough in their way, but of no practical value.

What, then, was comprised in such electrical exhibits as were found at the Centennial Exhibition in Philadelphia? Living there, and working in the electrical field, I remember that I possessed a lively mental sense of the ultimate vast utility of electrical forces which caused me to employ the opportunities afforded for study of such exhibits as from a practical or scientific standpoint showed distinct advances. There were in the main building a number of such exhibits as telegraphic apparatus and systems of signalling, electric clocks, burglar-alarms, and the like. In the class of philosophical instruments were the usual electric models for educational purposes. Electric key action was found applied to organs and automatic playing of the same. In Machinery Hall were to be found a few crude electric motors run by expensive and noisome primary batteries. Such motors were of but small power, and belonged to the old types, with electromagnets and bar armatures successively attracted or repelled. The application of dynamo-electric machines to electroplating, then in itself quite a novelty, was represented by Weston machines of fair size. In these machines some of the principles of modern self-exciting dynamos were found, but the armatures were of the old-style polar pattern with a single winding terminating in the usual pair of plates called a commutator.

But we need not further concern ourselves with these exhibits. They gave but small indication of the future of electrical progress. There was nothing in them to indicate or suggest that the world was on the eve of great advances so soon to be made.

There were, however, two exhibits in Machinery Hall of great interest to electricians as showing types of electrical machinery, which in various modified forms were soon to work revolutions in lighting and transmission of power. These two exhibits were of the Gramme and Wallace machines. Neither was remarkable for the floor space covered, but notwithstanding their modest extent, and the fact that they were sandwiched in between exhibits of entirely different class and widely separated one from the other, there was that in each of them which could not fail to be of deep interest to an electrical worker. The Gramme machine itself had become known in the United States through descriptions in scientific

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journals, and there had been two or three machines imported into the country. Two of these I had the opportunity of inspecting a year or two before. Another Gramme machine—built at Cornell University, if I remember rightly—was sent as an exhibit to the Centennial Exhibition. This was probably the first dynamo of the kind built in the United States.

In the Gramme space itself could be seen a small belt-driven dynamo giving current for the working of a single arc lamp in its circuit, series working being unknown at that time. In this space also there was an arrangement of circuit whereby one machine, driven by the belt as a generator, furnished current through some 20ft. or 30ft. of wire to a second similar machine, which then ran as a motor. This was, in turn, belted to a small centrifugal pump, which produced a small cataract of water. Experiments were also made from time to time in the heating and melting of wires by the current generated by the machines on exhibition. Special coarsely-wound low-potential Gramme dynamos for electroplating were among the interesting features. I remember the feeling of admiration—I might almost say exultation—with which I viewed this most unique exhibit. I also remember the enthusiasm of the attendant, whose voice held firmly to its French, and musically rolled off the catalogue of the capabilities of the Gramme machine, "la lumière électrique, la galvanoplastie, le transport de force motrice, la telegraphie," etc.

I need not remind the technical reader that the Gramme machines were the first dynamos of the true modern type constructed—the armature iron being circular in outline and preserving its relation to the magnetic field while rotating, and the winding thereon being continuous, with leads taken at intervals to a commutator of many segments. The result was a smooth unbroken current resembling that from batteries. While in these machines the core was a ring and the wire was wound over and through the same, the subsequently developed drum type differed from it only in the disposition of the closed armature winding all on the outside of the ring core instead of through its centre.

The exhibit of Mr. William Wallace was unique in showing a number of different types or forms of dynamo, while the Gramme machines were substantially alike in pattern. The Wallace machines furnished current for single arc lamps, for plating-baths, and were reversed and run as motors. This exhibit was very suggestive of types and forms which afterward came into general use, and, fortunately, the machines themselves were preserved and sent to the World's Fair in the present year—a retrospect, as it were, of the Centennial exhibit. Historically considered, such early models are now invaluable. Space does not permit any detailed reference to them. Some of them were used—as were the Gramme machines—for furnishing current to work large reflector lamps, similar to search-lights, mounted on the roof of Machinery Hall, on occasions of evening celebration, with fireworks and other displays.

The Centennial will be remembered in the history of electrical progress on account of the fact that the telephone of Alexander Graham Bell became then for the first time known as an accomplished fact. It spoke with a small voice, it is true, at the Centennial Exhibition, but the echo of that voice was heard over the civilised world. The telephone had been invented just in time to date its birth from 1876. Dr. Elisha Gray, who was close upon Bell in the invention of the telephone itself, was exhibiting his harmonic telegraph, a very ingenious multiple telegraph, but the chief interest soon centred on the instrument that could talk. With the advent of the speaking telephone there seemed to come about a general awakening to the capabilities of electricity in practical work. It prepared the public mind for the coming of new wonders. It attracted attention to other electrical enterprises, and to a large extent wiped out the factor of conservatism in relation thereto. Indeed, the telephone had scarcely begun to be used practically before the announcement of the invention of the Jablochkoff candle drew attention to the field of electric lighting, and in 1878 the Avenue and Place de l'Opera, lighted by electric candles, constituted one of the great achievements of the Paris Exposition year. The Jablochkoff candle did not, however, realise expectations; it was too costly, and soon gave place to ordinary arc lamps run in series. Much pioneer work in this field was done in this country by Mr. Charles F. Brush, of Cleveland, who in 1879 had as many as 16 arc lamps running in series from one of his well-known dynamos. A few other inventors were almost equally early in this work.

It was towards the close of 1879 that Thomas A. Edison succeeded in accomplishing the task which he had undertaken and upon which he had been at work for a year or two. This was the invention of a small electric light giving a light of about the same candle-power as a gas-jet, and capable of being run in multiple with many others, without requiring too large a current or too frequent renewals of the lamp. Such a lamp to be commercially successful needed to be of low first cost, economical of power, and easily reproduced in large numbers. No one unless he has been engaged in similar undertakings can begin to realise the amount of effort, self-sacrifice, and hard work which must have been required not only to perfect the lamp itself and the details of its manufacture, but to provide suitable generators, regulators, distributing systems, mains, safety devices, and the other things which go to make complete the electrical equipment of a lighting installation—a revolution in lighting means and methods. That Mr. Edison and his able assistants undertook and accomplished this work, the records of the numerous inventions in this field would be sufficient evidence, did we not have the fact of the actual accomplishment as a matter of engineering history.

It would be beyond the scope of the present paper to trace the history of the innumerable developments in the electrical field brought about by the effort and genius of a great army of workers, both here and abroad, between the year 1876 and the present. It must not be forgotten either that, aside from the great engineering triumphs which are from their practical benefits sufficiently prominent, electrical science, purely as a science, has expanded and progressed apace.

The advance, though a rapid one, has been sufficiently gradual to allow us to note the process as more of evolution than revolution. The great exhibitions held within the period between 1876 and 1893 have embodied more and more electrical arts and productions. Add to these the specially electrical exhibitions—as in Paris (1881), Philadelphia (1884), and Frankfort, 1891—and the growth becomes evidently a gradual unfolding. It was natural, then, not only that the World's Fair of this year should have been characterised by progress in all arts, but that it should have become more distinctively electrical than any preceding international display. It is to be doubted, however, if many were prepared to find that such dependence on the work of the electrical engineer would be shown.

Whether we regard the lighting of the vast areas and spaces in and around the great structures in Jackson Park, or the transportation by rail or water within its boundaries, or the distribution of power for various purposes, it was through the agency of electricity that these objects were attained. In fact, the great bulk of the steam power developed was to give motion to the dynamos for furnishing current for all the various uses to which in these days electricity has been applied. It is certainly no exaggeration to say that the vast amount of mechanical power developed and used at the World's Fair was mostly used for electrical purposes or transmitted electrically for its ultimate use. A vast area in the Mechanic Arts Building, covered with engines and dynamos driven thereby, directly adjoined the boiler-houses and formed for the time, as it were, the most gigantic electric station ever installed. From it was sent out current for several thousands of arc lights, for from 50,000 to 100,000 incandescent lights, for innumerable electric motors working elevators, driving machinery of all kinds, ventilating, for charging storage batteries, for electric welding, forging, heating, and other uses.

At the Centennial in 1876, no perceptible fraction of the power was electrically used. At the World's Fair it had become almost wholly electrical. The arrangement of the great Corliss engine at the Centennial was in the middle of the Machinery Building, and by a complex system of gears and belts the power was transmitted and delivered to the long lines of shafting extending each way from this central power source. This was a limitation of service arising directly out of the absence of electrical transmission. At the World's Fair, on the other hand, power could be delivered anywhere by the use of electric motors, and the moving machinery was not therefore practically restricted to a building in which a steam-engine was at hand.

In 1876 arc lights were a curiosity and but rarely seen. In 1893 their use for illumination of streets and large spaces is almost universal. Never has there been, however, any greater display of arc lighting than in the present year at the World's Fair. The whole of Jackson Park was dotted over with these miniature suns at night and the interiors lighted. Under the roof of the Manufactures and Liberal Arts Building were five large coronas comprising many arc lamps each, a unique display in itself and an economical arrangement as well. About 2,000 arc lights, if I mistake not, were employed in lighting the gigantic structure throughout. The great search-lights, with their 60in. mirrors reflecting the light from specially large arcs in their foci, were a striking feature of the illuminations, and these artificial sunbeams were of an intensity never before approached.

The whole art of lighting by electric incandescence has come into existence since 1876. Incandescent lamps can now be made of such uniformity of voltage and energy consumption as even to dispense with any need of photometric measurement, and, indeed, to require no testing or sorting after manufacture. Such lamps may consume about 3½ watts per candle and have a useful economical life of over 1,000 hours of service. An achievement like this means attention to many small details, and the doing of delicate work on a large scale. Astonishing it is to find that frequently in such work, what was formerly a delicate laboratory manipulation becomes every-day workroom practice; and here constant practice of delicate operations by even ordinary labour results finally in almost perfection.

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The larger part of the incandescent lighting of the World's Fair—and the little bulbs were everywhere used and useful—was carried out on the alternating-current plan so commonly employed in cities and towns where the electric station must be at a considerable distance from the mass of consumers. Huge dynamos in the Mechanic Arts Building supplied the alternating current at high pressure in mains leading to the transformers, located in receptacles in the ground, from the secondary circuits of which the low-pressure currents were fed to the lamps connected thereto.

At the time of the Centennial, alternating currents were known, and dynamos yielding such currents were known, being among the earliest invented, but the transformer was unknown. The nearest approach to it was the induction coil for shocks or medical use and the Ruhmkorff coil. Soon after the invention of the telephone, however, the induction coil, modified and used in conjunction with carbon transmitters, enormously increased the distance over which speech could be successfully transmitted, and has led in 1893 to the regular communication by telephone over distances more than a thousand miles, while such is the delicacy and fidelity of transmission that it is not necessary to speak much above a whisper at New York or Boston to be heard in the receiver at Chicago.

The transformer, or modified induction coil, has in like manner render possible the economical transmission of electric energy to great distances, as the working of low-voltage incandescent lamps at miles of distance from the supply station. Otherwise, the line losses and excessive cost of mains would in such cases forbid the use of direct supply. The perfection to which this useful apparatus, the transformer, has been brought by careful work may be judged from the fact that it often has an efficiency between 97 and 98 per cent. at full load. It is a simple affair of copper wire and sheet iron apparently, but it has required much study and experiment to bring it to the present state of perfection. There is little or no opportunity for further advance. The very great expansion of incandescent lighting both by the direct-supply systems and transformer systems during late years is sure to continue at an increasing rate in the future until it includes a large proportion of the lighting done in cities and towns.

In 1876 the storage battery was practically unknown. A crude form devised by Planté had been experimented with for a considerable time before in the laboratory. The eminently successful use made of the electric launches on the lagoons at the World's Fair was an ample demonstration that in the past few years a new field for electrical work had been opened up. The application of the battery to boats is of course but one of the uses for the modern storage cell. Many electric stations in Europe, and a few in the United States, have within late years added an equipment of batteries to work in conjunction with their dynamos in giving out current energy when the consumption is heavy, and to absorb energy or become charged from such machines when the consumption is small. This in a large measure prevents overloading at one time, or the running of the machinery with loads too light to be economical at other times. How far experience will confirm the apparent advantage of such a plan remains to be seen.

The largest single exhibit of an electrical nature was without doubt the Intramural railway and its power-house—together a grand practical exemplification of electricity applied to traction. It was remarkable in many ways as a piece of engineering and operated with the greatest success. It emphasised the fact that the days of steam locomotives on elevated roads in cities are numbered, and that just as surely as the horse-car has given place to the trolley-car, so must the electric motor supplant steam propulsion on the roads in question. Yet in 1876 there was no hint or suggestion of such extended use of electricity on railways—and, in fact, no such applications had been made. On the Intramural road a conductor rail with the ordinary rails for return circuit was used, the current being taken up by sliding shoes bearing on the conductor rail. The motor-car at the head of each train, besides the ordinary seats, was provided with four electric motors, one geared to each axle individually, while the controlling mechanism was arranged so as to connect the motors in single series for starting and to make successive changes passing through intermediate connections until the one having all the motors in parallel was reached, the condition for maximum speed.

This arrangement, with refinements of details especially designed for this work, and first put into full operation at the World's Fair, gave great economy as well as flexibility in the handling of the trains. One of the best illustrations of the progress in the art of electrical engineering in the past few years was the building in the station of the Intramural road of the great direct-coupled continuous-current dynamo of 2,000 h.p. capacity. This machine—by far the largest continuous-current dynamo ever made—was designed by Mr. Horace F. Parshall. It is a comparatively simple undertaking to design and construct very large alternating-current generators, since in many respects they are like duplications or enlargements, simply, of the elements of smaller similar machines. This is not so with continuous-current types, as the problems of armature reaction, air-gap, and self-induction as affecting the working of the commutator at various loads have to be carefully estimated, while the relation of turns on the armature to number of segments in the commutator, the proper proportions and construction of the commutator itself, and the other proportions, have to be studied with great care and adjusted within limits. All this makes the production of so large a machine, built, as it was, without previous experiment, and its parts put together, even to the assembling of the sheet-iron pieces of the armature, in the station itself, a veritable triumph of engineering skill.

Speaking generally, it is not far from the truth to say that at the World's Fair there was as much to be seen of electrical application outside of the Electricity Building as within its walls, though this building was itself a temple of electricity. There were, it is true, a number of exhibits of no special significance, such as those of shifting light in masses of incandescent lamps, obtained by complicated switching appliances, coloured lamps being freely used. The most artistic display of the kind was the Edison tower of lights, a creditable piece of work, the effects obtained from which were certainly very striking and beautiful. The large and varied display of modern electrical apparatus and machinery, together with the various historical exhibits, were of deep interest to the student or engineer. There were found a fully-equipped modern telephone exchange and also Dr. Gray's "telautograph," which is in a certain sense an intended rival of the telephone. There also were found many types of dynamos of various makers both here and abroad. Electric motors were found applied to all manner of work—pumps, hoists, elevators, locomotives, and mining machinery generally. Electric arc lamps and machines, carbons, of all leading makers, were here together with exhibits showing many forms and patterns of incandescent lamp—lamps of low voltage to lamps of high voltage, lamps with one filament to lamps with a dozen filaments, lamps of 1 c.p. to lamps of hundreds of candle-power, etc. There were full lighthouse equipments with their huge compound lenses on view. On the one hand was to be found appliances for generating electricity of enormously high pressures, such as would leap in torrents of sparks over more than 5ft. of clear air space, and, on the other hand, apparatus for electric welding and metal-working capable of yielding currents of 50,000 amperes with pressures as low as two or three volts. The comprehensive exhibit of practical work done in electric welding, including the largest weld ever made by electricity, in which the section at the weld was 48in. of steel, was of great interest to many practical men.

A number of creditable exhibits of alternating-current motors of such types as single-phase, diphase, and triphase construction were found, so that the respective characteristics of this most interesting of the recently-developed forms of alternating-current apparatus could be examined. This class of electric machinery is of so recent production that we must look to the future for its wide application. Everywhere in Electricity Building was evidence of the enormous growth of electrical industries. It could be partly understood from the variety of such things as switches, safety cut-offs, wires, cables, insulating materials, found there, aside from the heavy machinery.

In the department of measuring instruments alone, the progress to be noted was remarkable. Ammeters, voltmeters, wattmeters, recording wattmeters, standard resistances, standard cells, electrical balances and bridges, of the highest degree of excellence, were not wanting. With the refined means of measurement so provided the estimation of electrical forces and quantities may be made with a rapidity and precision hardly equalled in any other department of physical science. Enough has been said, however, to indicate what a harvest has, in the past few years, been the outcome of the earnest effort of brain and hand in the electrical field.

The one discordant note in all this great display of genuine scientific and engineering work was found in the fact that in this same temple of science—in Electricity Building itself—naked imposture, quackery in the form of so-called electric belts, hair-brushes, insoles, and what not, had obtained a footing and stalked forth unabashed. No words of condemnation can be too strong to be applied to the parasites who, in the guise of healing and benefaction, succeed in extracting perhaps the last money from the sick and suffering for their worthless trumpery. The fact that such exhibits were found in 1893 holding place alongside of genuine electro-therapeutic appliances of undoubted merit only heightened by contrast the great shame of their presence.

Within the limits of the present article it has manifestly not been possible to do more than briefly refer to such electrical features of the World's Fair as show in concrete form the great advances which have taken place since the Centennial year.

Our technical schools and universities now devote to the teaching of electricity as a branch of engineering special courses, special laboratories, special instructors. Formerly the little electrical knowledge taught was taken up as a department of physics.

In this present year, the arc lamps in use are numbered by the hundred thousand, incandescent lamps by the million, while millions of passengers are carried daily on electric cars,

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thousands of horse-power transmitted and distributed by electric motors, thousands of tons of metal refined annually by electrolysis, chemical decomposition on the large scale effected, as in the production of cheap aluminium, electric furnaces are turning out their special products, such as carborundum of diamond-like hardness, and electric welding and metal-working machines are in active service in a large number of manufactures.

In summing up this great growth we must not forget the enormous extension of telephone-service systems in the past few years. So great have been the advances that it is natural to expect that in the immediate future similar rapid and important work will be undertaken and accomplished. It is difficult to play the *rôle* of a prophet unless the prophecies be made so numerous that some of them cannot fail of realisation. There are, however, some things concerning future electrical development about which we can be positive. It is not likely that, except in details, much advance will be made in dynamos and motors. The efficiency of well-designed types is now so high as to leave very small opportunity for improvement. Large dynamos at full load have commercial efficiencies ranging from 95 to 97 per cent. Transforming apparatus of various types may readily have at full load a net efficiency of 97 per cent. The possible efficiency of arc lamps is about reached—and with the incandescent lamp the volatility of carbon at high temperatures governs the efficiency and life. The higher the temperature the more efficient the lamp, the more volatile the carbon of the filament, and the less will be the life of the lamp. It is unlikely that any better material than carbon will be found for the filament, and the properties of carbon as to volatility can probably not be changed.

The cost of these lamps is now about as low as is consistent with good quality and uniformity. The use of transformers for raising or lowering the line potential, permits long-distance transmission of electric energy with moderate loss. The conditions of the most efficient use and operation of electric motors as a source of power when transmitted have been well worked out, so as to leave but little further to be accomplished in that line.

We can hardly expect therefore to make any radical gain in the operation of electric plant unless by the utilisation of new principles in unexplored fields. A substantial gain in the economy of the development of power from fuel is of much greater moment than any possible gain in the efficiency of the electric plant. Hence electricians are looking for cheaper power, as that, and that alone, now means cheap electricity. For the same reason attention is more than ever concentrated on the utilisation of water power, as of Niagara itself by the Cataract Construction Company. Much future work will be done in this field, and it will give rise to many new problems for solution by the electrical engineer. The laboratory work of to-day becomes engineering work of to-morrow. Work which to-day is in the experimental stage reaches its full commercial completeness only after considerable practice with it under varying conditions. The advance work goes steadily on, but in channels which demand more and more intricate knowledge of electric actions. It is the fervent hope of many an electrician that, at no very distant time, the energy of fuel may be converted more directly into electric energy, and without the enormous percentage of loss that is involved in present methods, and that some means may be found to further transmute the electric energy into light with but a small percentage of dark heat, instead of present wasteful methods; but this is still a hope only, and there is not even a probable solution indicated.

In the department of electrical engineering work, the early future will I think witness, in addition to a constantly increasing use of electricity for illumination, further application to chemical and metallurgical work. The field for the application of electricity to mining, for hoists, for pumping, drilling, mine haulage, and the like, is very wide. While it is not probable that the steam locomotive for long-distance railroading will soon be supplanted by electric locomotives, still there is a growing interest in these latter as applicable to special cases, such as specially-designed high-speed roads between populous centres, for tunnel work, and elevated roads in cities. As feeders for trunk lines of railroad it would seem that trolley lines are admirably adapted both for passenger and freight service, and their employment in this way will doubtless become of great importance in densely-peopled localities.

There is also a field for the application of electricity stored in batteries to propulsion of road vehicles—a field in which but little has hitherto been done. Electricity generated under present conditions, involving in the first conversion into mechanical power such an enormous loss of heat energy of the fuel, will evidently not be applied as a general heating agent. In certain cases, in which the disadvantage of high cost may be outweighed by superior advantages of application, as in cooking by electric heat, there may result a considerable extension of its usefulness. But that it can be economically applied simply to heat metal bars for forging in a drop-press or rolling-machine, is not at all to be expected. In special cases of distinctly local heating of metal for welding, bending, or other process, it is now not only used with success and economy, but it would appear that many additional applications of this kind will be made in the future.

While it may be reasonable to look forward to the ability to telephone through an ocean cable under the Atlantic, it is hardly likely that we shall travel over it in ships propelled by electricity. It would indeed be possible to construct electric motors able to turn screws and propel our largest ships, but the supply of current energy to them at the rate of 10 h.p. to 20,000 h.p., for five days continuously, would require a storage battery to be carried such as would be enormously costly and so heavy that it could not be placed aboard without sinking the ship. It should, however, be borne constantly in mind, in dealing with the subject of electrical applications, that a new discovery might at any time change the aspect of every prophecy based on present knowledge and conditions.

HULL.

The advantages of electric traction are gradually being considered by various authorities, and among those who have taken definite steps may be named the Hull Corporation, whose electrical engineer, Mr. A. H. Gibbings, has collected information for the enlightenment of the authority. We cannot give Mr. Gibbings's report in full, as a portion of it consists of extracts from various publications—many, we are glad to see, from our own pages—but we give those portions which will assist our readers to the complete history of the movement in Hull. Thus the committee report:

The Electric Light Committee having received a letter from Mr. Priestly, of Halifax, stating that he wished the committee to visit Halifax and view in operation his system of utilising the steam produced from the heat generated in burning town's refuse, which he claimed would materially economise the production of electricity for lighting, it became the Electric Light Committee's duty, under its function "to watch the progress of electricity in its application to light and power," to investigate this and other letters of a like nature, the result of its considerations being that the chairman was desired to invite Dr. Alderman Fraser, the chairman of the Sanitary Committee (which has control over the refuse destructors), and Mr. Alderman Larard, chairman of the Works Committee (which has management of the tramways negotiations), to meet him and discuss for the benefit of the town the value of co-operation in work on the three subjects of working electricity, refuse destructors, and tramway traction. The chairman of the Electric Light Committee having desired Mr. Gibbings, the borough electrical engineer, to collate all printed matter, letters, and obtain by correspondence any other information important to the consideration of these subjects, the conference of the interested chairmen was held at the electric light office in December, and their report, founded on their discussion (and the report of the electrical engineer, which is printed *in extenso* in the Electric Light Committee minutes for the Council meeting), is hereto appended:

Report to the Electric Light, Works, and Sanitary Committees on Refuse Destructor, Electric Lighting, Traction, and Tramcars worked therefrom.

Having read and duly considered the report of the borough electrical engineer, and the many important letters upon which it is founded, the committee of chairmen above named feel that the utilisation of steam generated by refuse destructors is practical They consider its application is likely to become useful, with or without the aid of coal, in producing electricity cheaper. From its recent rapidly-enlarging practicability of application, it seems that its steam-producing powers may be better applied to the economical charging of accumulator batteries, for the running of self-contained electrical tramways, which system appears to be the best designed for such a town as Hull, with its dock lock-pits and narrow streets, than to electric lighting. In the future they think it could be used economically in some situations in the town to that purpose. Electrical lighting requires a constant generation of heat, which the committee is not certain, without further investigations, these destructors can afford. Electric accumulators for tramway traction may, however, be charged at any time when the heat and steam are available, and used from the cells when and where required. The working of self-contained electrical tramways from the steam produced at town refuse destructors does not seem to have engaged much attention, but the committee feels the constant improvement taking place in these destructors tending to steam generation, and the lightening, combined at the same time with the strengthening and efficiency, of the electric cell plates, as shown in the communications of the Messrs. Epstein, and especially Messrs. Mather and Platt's letter, detailing the improvement in the cells which have been working tramcars successfully for two years in Paris, afford the liveliest hopes that economies in tram traction even now hold out the idea of profitable employment in a town like Hull, which, as the engineer's report points out, would have the benefit over Birmingham of having no gradients to work, and the advantage of economies in steam production from town refuse waste heat, not yet applied for tram traction, which would only

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entail the cost of plant, and which must economise in the cost of coal.

The committee agree that the matter of making further provision for the destruction of town refuse can, wisely and profitably to the town, be considered together with electric lighting and tramway station centres, for it affords a hope that by the formation of new electric light distributing centres, combining tramway cell charging and refuse destructor, with mortar-mill stations, the three things can be most profitably used to the advantage of the outlying districts of the town as opportunity offers.

The committee think that it would be wise, and much practical information would be obtained, if this was investigated further, and suggest the invitations of Mr. Priestly, Messrs. Babcock and Wilcox, Messrs. Epstein, and Messrs. Mather and Platt, to visit the destructors, steam generators and accumulator cells, and electrical tramways, be accepted; and that a committee, consisting of two members from each of the Electric Lighting, the Works, and the Sanitary Committees, should be nominated for this purpose and to report thereon. They recommend this to their respective committees and the Council in the belief that it will be profitable to the town that these promising systems shall be investigated in operation apart from experts, who are often interested and naturally biased in favour of their own productions.

EVAN FRASER,
Chairman of the Sanitary Committee.
FREDERICK LARARD,
Chairman of the Works Committee.
WILLIAM HOLDER,
Chairman of the Electric Light Committee.

The following extracts are from Mr. Gibbings's report to the committee *v.* pamphlet:

Gentlemen,—I have now pleasure in placing before you the accompanying list of places which are using, or proposing to use, electric tramcars, with the experience, as far as I have been able to ascertain, of those who have had the management of them. You will note, in the first place, that all electric tramway enterprises so far in this country, and all statistics, have been carried out and based upon specially-constructed plant and stations where coal is used as fuel, and no trial has been given to supplying energy in a cheap form from refuse destructors or water power. Also another most important point—namely, that very few districts are so level and flat as the town of Hull, and this will soon make a difference of 50 per cent. in calculating working costs. You will, however, best gain an idea as to the three different systems from the following details attached, and letters from various individuals particularly interested or otherwise. The information with reference to dust and refuse destructors requires very little comment. There should be no difficulty in obtaining exactly what is required, as when once the steam-generating capacity is ascertained, the power obtained may be applied to electric lighting, electric traction, or other purposes.

LIST OF TOWNS WHICH ARE, OR HAVE BEEN, CONNECTED WITH ELECTRIC TRACTION.

Town.	System.	Remarks.
Aberdeen	—	Proposed to run to sea-beach only.
Bradford	Overhead ...	Experimented, but not adopted.
Birmingham	Accumulator	In operation for 12 months.
Blackpool	Underground	Run on sea-front promenade only.
Croydon	Accumulator	Small experiment with two cars only.
Coventry	Overhead ...	No information.
Douglas	—	Proposed electrical railway already running.
Leeds	Overhead ...	In operation two years. Three miles of line in one direction.
Matlock	—	Proposed.
Newport (Mon.)	—	Proposed.
Paris	Accumulator (special patent)	In operation two years. Financed by Messrs. Rothschild and Sons. Very satisfactory results
South Staffordshire	Overhead ...	—
Southport	—	Proposed.

You have now the preceding particulars to go upon, and to make use of in whatever way may suggest itself to you. I think it would be as well, however, to remind you that the information has been obtained in a hurried manner from all sources available, but you have before you for comparison the experience of the users and the statements of the advocates of the various systems. To roughly summarise, we can take each system separately, as follows:

1. *Overhead Wire.*—This is no doubt an economical system, and a comparatively safe one, as no disturbance of the roadway need take place. Still it is liable to great damage from bad weather, and is unsightly. In our particular instance the great difficulty would be in crossing the dock bridges.

2. *Underground System.*—This is the most expensive system in first outlay, and under the stringent regulations proposed by the Board of Trade upon underground traction mains, it would no doubt be a source of expensive maintenance also. Moreover, the same difficulty in crossing the dock bridges would have to be met.

3. *Accumulator System.*—This system appears to me to be the one best suited to the town. The drawback to all electric traction is when used in steep and hilly districts, from which we are peculiarly free, and therefore the strain on accumulators would be steady. Also, this form shows good working results in Birmingham, which is a hilly district, and the system has paid expenses of management, which include large offices with a managerial and secretarial staff. I also think suitable arrangements could be made with a contracting company in order to ensure the venture being a paying one, in any case, say, in 12 months, but there can be no doubt that in the hands of a committee the managerial and working expenses could be so arranged that it would pay the Corporation best to entirely work their own system.

The most important point, however, is the advantage of being able to supply energy in a most economical way from refuse destructors. If refuse destructors were used for either of the other systems, a constant supply of current at a constant pressure would have to be kept up, which would be somewhat difficult at times, but in charging accumulators the night time could often be made available to suit conditions of requirements. Also these destructors could be erected at tramway termini, and very convenient arrangements effected in every way. While these destructors would be in course of erection, the large amount of available energy in the daytime at our central station could be made use of to the advantage of both tramway and electric lighting enterprise.

In conclusion, I have only to point out to the committee that other towns are ready and willing to receive the committee and explain to them the working of systems which have been in operation for some time. The following summarises the advantages over other methods of accumulator traction, combined with the use of refuse destructor and the present electric lighting plant: 1. Much smaller original capital will be required, as there will be no mains to lay in the roadway, nor any rails to electrically connect together at their different lengths. Also, the maximum capacity of the generating plant will be smaller, and therefore cheaper, extending over a greater number of hours in working, which would then, of course, have a higher efficiency than a larger plant working at shorter periods. 2. A less cost of working, instead of increased cost, can be obtained by using double lines throughout, as there will be no stoppages and stand-bys on loop lines for other cars to pass. 3. Accumulators have a higher efficiency on a level road than other methods in places where there are steep gradients, in comparing the three systems in such places. 4. Arrangements for charging batteries can be conveniently made to suit the other demands on the charging station, thereby greatly increasing the efficiency of the charging plant. 5. Total avoidance of the Board of Trade regulations, and consequently less expense in management, which regulations are calculated to impede the progress of electric traction. 6. Smaller plant, fewer instruments, and easier management at the central station. 7. Any breakdown confined to individual cars. 8. One conductor, small cars, quick service, and in consequence easier travelling than on either underground or overhead system. 9. No expensive maintenance. 10. No engineering or electrical difficulties to solve in rounding curves or other obstructions. 11. Smaller capital, hence larger dividend per cent. 12. The losses in charging the batteries compare favourably with losses in the mains of other systems through transmitting steady pressures over a long distance, and also through starting and stopping on other systems, as the regulation of the current with accumulators is not attended with loss through resistances as when current is taken off mains, the regulation being effected by putting more or less cells in series as required. 13. All spare power generated can be utilised for supply of electric light and current in the districts outside of the present area of supply, thus making the destructor plant highly remunerative.

The future of electric trams of which the motive power is accumulators can not only be assured, as seen by the foregoing report, but the above letter [referring to a new type of accumulator, to the particulars required for tender, and mentioning that in France the Rothschilds are interesting themselves in the work] indicates at once the progress which has been made during the past two years, and the general tendency, for obvious reasons, towards this form of traction. The fact of the adoption of this system in Paris, a city where overhead or underground mains would not be tolerated for other reasons than apply in your town, together with the well-known firm who are financing the undertaking, is a large guarantee of its commercial value, and it no doubt forms the latest and best-developed instance of electric self-contained tramcars. I feel this is of the utmost importance, and think it ought to be embodied in the above report, which I could not do in presenting it to your sub-committee, as the matter was not then before me.

ELECTRIC LIGHTING AT FOLKESTONE.

A special meeting of the Folkestone Corporation was held on Wednesday of last week to receive and consider the report of the Electric Lighting Committee.

The **Mayor**, as chairman of the committee, formally moved that the report be received, and Councillor **Payer** seconded the adoption of the report, of which the following is a copy, signed by Councillor Geo. Evan Thompson and Mr. W. G. S. Harrison (the town clerk):

"Your committee was appointed on the 19th of April last to consider and prepare a provisional scheme for the public and private lighting of Folkestone with the electric light, with power to consult an electrical engineer and to pay him a fee for his

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services not exceeding 50 guineas. Having taken all the necessary steps to obtain reliable information upon such an important and highly technical matter, it has now the pleasure to report as follows: Acting upon the authority conveyed in such resolution, the services of a consulting and electrical engineer—Mr. Mark Parker, of Rochester—were retained for the purpose of advising the committee upon technical and other details. It should, perhaps, be mentioned, for the information of the Corporation, that Mr. Parker is not only an electrician, but is also a practical engineer, and has had some 15 years' experience in electric lighting work, during which time he has designed, constructed, and acted as manager of electricity supply works. In his remarks and in his discussions with your committee he has shown himself thoroughly conversant with all the details in connection with electric lighting, and your committee has also received testimonials testifying to the success of his past work and to his ability to advise the committee upon all matters pertaining to electric lighting. In addition to discussing with the committee the various details involved in providing a supply of electricity, Mr. Parker has presented it with an able and useful report, which, however, is too voluminous to lay before the Corporation, but it may briefly be said that it describes the various systems of electric lighting now in operation, their respective advantages and disadvantages, and being accompanied by diagrams, the entire subject has been presented in a clear and intelligible manner, and your committee has subjected this report to its careful and searching investigation. In addition to this report, three of the members of the committee (Councillors Penfold, Spurgen, and Pursey) have, at their own cost, paid visits of inspection to the following places where installations have been established—viz., North-Eastern Railway at York, House-to-House (West Brompton), Leeds, Hastings, and more especially to the installation of the city of London electrical supply; that installation is being worked on the same principle and lines as that recommended by your committee in this report, and the information obtained by them on such visits has materially aided your committee in their labours. Your committee scarcely think it necessary, specifically, to point out all the advantages of the electric light over that produced from gas and other illuminants. It is doubtless already known to the members of the Corporation that by the use of electricity as the lighting power the air is not vitiated or consumed—the heat given out is only one-twentieth of that radiated by gas; ceilings, decorations, and furniture are not discoloured or injured, great cleanliness is ensured, and in shops and warehouses where valuable or perishable goods are stored it will be highly appreciated, and altogether it is safer and more economical. Your committee will therefore proceed to the other important points—viz., the advisability of its introduction into Folkestone, and the best mode of so doing and working the same.

"(1) As to its advisability.—Your committee is of opinion that there already exists a sufficient demand for the supply to warrant the erection of an electrical installation. Enquiries have been already made by several establishments in the town as to the cost of erecting private installations, and arrangements have also been already made for its actual use in the mansions now being erected on the West Leas.

"(2) As to the powers for carrying out the necessary works.—Your committee is of opinion that it should undoubtedly be carried out by the Corporation, and that it would be extremely prejudicial to the best interests of Folkestone if the Corporation were not to do so, and to allow statutory powers for the purpose to be granted to private undertakers, which will be the probable result if the Corporation decides not to apply for powers or defer proceeding at once with the installation. This must certainly not be done. Your committee, after much discussion, is satisfied and is strongly of opinion that it is undoubtedly advisable to introduce the electric light into Folkestone both for public and private purposes.

"(3) As to the system for adoption.—Your committee has given this point its study and attention, and recommend the adoption of the high-tension alternating-current transforming sub-station system as best suited to the circumstances of Folkestone. This system secures all the advantages of the high and low tension distribution.

"(4) The area of supply.—Your committee advise that the first section shall be confined to the following streets: Sandgate-road, from Town Hall to Earl's-avenue; Church-street, from Town Hall to Priory-gardens; the Leas, from Priory-gardens to Earl's-avenue; Guildhall-street, from Town Hall to Shellons-street; Rendezvous-street, from Town Hall to Tontine-street; Tontine and Harbour streets and Marine Parade to Victoria Pier; the cross-streets from the Town Hall, between the Sandgate-road and the Leas; Castle-hill-avenue to Shorncliffe-road. A plan of this area is annexed hereto showing the exact position of the public lamps and the distribution of mains for the private supply.

"(5) Capacity and cost of plant.—The total capacity of the plant your committee advises should be an installation of 490 kilowatts (a technical expression iu electrical science), 280 of which would be in constant action, and the remainder 210 would form a reserve to meet demands for further supply within the borough as occasion arises for the electric supply. A kilowatt is 1,000 watts A light of 8 c.p. requires 30 watts burning an hour. The capital sum for this plant would amount to £35,000, a detailed estimate of cost, annual working expenses, and probable revenue will be found at the foot of and annexed hereto (estimate No. 4).

"(6) Public lighting.—Two schemes for this purpose have been under the consideration of your committee. No. 1 proposes to use 80 arc lights of 2,000 nominal candle-power placed in the position marked on the plan above referred to. No. 2 proposes a combination of 80 arc lights and 160 incandescent lamps of 25 c.p. each. This method is adopted at Brighton, and is being adopted at Portsmouth, and consists of the attachment of two incandescent lamps to each arc pole, the arc lights being extinguished at 10 or 11 p.m., when the incandescent lamps would be lighted. This system has the advantage over No. 1 as regards cost, being about £200 less per annum than would be the cost of No. 1, but taking all the points into consideration, your committee recommend for adoption the system No. 1. The illuminating power of system No. 1 would be 12 times that at present received from gas, and would cost about £300 more than at present. The illuminating power of system No. 2 would be seven times that at present derived from gas, and would cost about £120 more than at present, but the enormously increased illuminating power is a full compensation for this extra cost. A table showing these comparisons, and the annual cost of gas and each of the above systems, is appended to this report.

"Your committee now begs to conclude with the following recommendations which it submits with confidence for the approval and confirmation of the Corporation.

"1. That the introduction of the electric light into Folkestone should be at once proceeded with, and that it should be undertaken by the Corporation itself.

"2. That the Corporation should in the first instance undertake the supply of electricity under a Board of Trade license, and that application be made forthwith to the Board of Trade for such license under the Electric Lighting Acts of 1882 and 1888, and that the Electric Lighting Committee be authorised to do all that is necessary for that purpose under the advice of the town clerk.

"3. That electric lighting works be established with the necessary plant, machinery, and appliances, and that proper mains be laid under the public streets and thoroughfares in accordance with this report.

"4. That the system of distribution employed be high-tension alternating-current transformer sub-station system, by means of which all the advantages of both high and low tension distribution will be secured.

"For lighting the public lamps arranged in series by means of currents, synchronous commutators should be employed for the purpose of redressing the alternating currents as required.

"5. That the capacity of the plant be 490 kilowatts in accordance with this report and estimate No. 4 attached hereto, 280 of which (as stated above) will be in constant action, and the remainder, 210, will form a reserve to meet demands for future and further supply as the occasion for the electric supply arises.

"6. That the area of supply be in accordance with this report and plan annexed hereto.

"7. That the services of Mr. Parker be retained on terms to be arranged between him and the members of the Electric Lighting Committee (subject to the confirmation of the Corporation) for the purpose of advising and assisting the committee and the town clerk in obtaining the proposed license, in designing the necessary generating and distributing works, in advising the committee with reference to the acceptance of tenders, supervising the construction, and laying down all plant, etc.

"8. That the committee be authorised to instruct Mr. Parker to prepare all plans, specifications, bills of quantities, to obtain tenders for constructing and laying down the proposed work, and thereupon to prepare and submit for the approval of the Corporation such contracts as the committee think advisable for the supply, construction, and erection thereof, and for laying mains under the public streets and thoroughfares.

"9. That the committee be authorised to select a suitable site upon which to erect the proposed electricity generating works, and to negotiate under the advice of the town clerk for the purchase of the same subject to the confirmation of the Corporation.

"10. That upon the license above referred to being granted, the town clerk do immediately apply on behalf of the Corporation to the Local Government Board for sanction to borrow £35,000 for the purpose of the above works, and the result of such application be submitted to the Corporation for confirmation.

"Summary of the financial position under this report, and of the estimated income and expenditure in respect of the area designated in this report and the plan:

Estimated total cost of the generating plant as per estimate No. 4				£35,009	0	0
Estimated income—public lighting	£1,536	0	0			
Private lighting	8,121	0	0			
Total				9,657	0	0
Estimate of working expenses, including coal and other material, salaries and wages, rates and taxes, and incidental expenses	6,192	0	0			
Interest and sinking fund, say, 5½ per cent. on the cost of £35,000	1,925	0	0			
				8,117	0	0
Credit balance, per annum				£1,540	0	0

"We have carefully prepared the above written report from data supplied to the committee during its investigation, and recommend its adoption by the committee."

Various tabulated statements were appended to the report.

A memorial was read from the west end residents of Folkestone petitioning the Corporation to instal the electric light, and urging the necessity of its being done with as little delay as possible. It was signed by 166 persons.

The report was discussed at some length, and its further consideration was adjourned for three weeks, so that some idea of the number of lamps required by private consumers might be obtained,

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COMPANIES' MEETINGS.

FOWLER-WARING CABLES COMPANY, LIMITED.

The fifth ordinary general meeting of this Company was held last Friday at the offices of the Company, 32, Victoria-street, Westminster, under the presidency of Mr. Wm. Fowler (chairman of the Company). After Mr. D. Stephen (the secretary) had read the notice convening the meeting,

The **Chairman** moved the adoption of the report and accounts, which were published in our last issue. In doing so he expressed regret that they were unable to pay any dividend, and stated that the directors had on this occasion waived their fees for both past and the present year. Thus they showed their disposition to assist the Company in every possible way, to say nothing of the fact that they had helped the Company by loans made to it. The real cause of the lack of dividend might, he thought, be stated to be the general depression in all businesses during 1893, and to the great competition there had been for orders in the electrical industry. The general condition was so fully set forth in the report that it would be unnecessary to enter into details. The balance-sheet had been very carefully drawn up, and everything had been taken with the intention of showing the shareholders exactly how the matter stood. They had not made out a profit that was not actually made, but showed a genuine one. All they wanted with their admirable factory and machinery of every kind was a larger amount of orders. He thought they might hope that the year before them would be a better year than the last. Another point was that they still required additional working capital. The directors were endeavouring to raise that in a way which they hoped would be satisfactory, but if they did not succeed in that they might again have to appeal to the shareholders for assistance. So far they had obtained practically no help from the shareholders, but he trusted that if it was absolutely necessary they would be willing to come to the aid of the directors. The management of the Company had been extremely able, and his impression was that they could not appoint a better man than they had got. They had every year additional confidence in his management of the Company, his energy, industry, and ability. He hoped with that management they would still make this a successful Company.

Mr. Walter Fletcher, in reference to the remarks made about the depression in trade, said that wherever one travelled new electric systems were being laid down, and he had rather expected some sort of explanation of the want of success on the part of the Company in the face of this enormous increase in electrical work. To an outsider there had never been such a busy time for electrical work, and he was wondering whether the Fowler-Waring cable was the best adapted or whether it was getting superseded by others. If that was so, looking at the balance-sheet, would it not, he suggested, be better to at once wipe off from one side of the sheet "by patents and goodwill, £41,000"? It was only a paper asset. He would like to know something of the turn-over, of which the directors gave the shareholders no idea.

The **Chairman**, in reply, admitted that there was great activity, but there had been depression even in the electrical world. With regard to the turn-over, they did not generally publish particulars, but he would give them the figures privately after the meeting. The turn-over last year was considerably greater than in the previous year, but the profit was not so large proportionately, the reason being that, owing to competition, the estimates had to be made on a less profitable scale than in former years. Concerning the suggested reduction of capital, it would be necessary for that to go to the court, and that would be objectionable, and would tend to affect the credit of the company. He then called upon

Mr. Alfred E. Mavor, the general manager, who referred to the presidential address of Mr. A. Siemens delivered the previous evening, and which showed clearly the reasons why electrical enterprise had been kept back and hampered by many causes. During the latter months of 1893 business had been recovering, and it might be as well for them to know that the Company were disturbing the streets and laying mains in London and other towns. He had absolute confidence that their cables held the very first position. He would not say that there were no other cables so good, but comparative trials had demonstrated that they were in the first rank as cable-makers. It was impossible to say whether the asset of £41,000 was too large or too small, and he did not think that that sum would appear a very large amount for the ultimate goodwill of the Company. He thought they were thoroughly in a position to compete with the greatest of their rivals, and so far as they had gone they had equalled some of the best of their work.

The motion for the adoption of the report and accounts, seconded by **Lord Medway**, was then put and carried. The Lord Medway and Mr. Geo. F. Smart, the retiring directors, were re-elected, and Messrs. Cooper Bros. and Co., the auditors, were reappointed.

BUSINESS NOTES.

Llandrindod.—This town is considering the question of going in for the electric light.

Western and Brazilian Telegraph Company.—The receipts for the week ended January 12 were £3,297.

Porthcawl.—The Porthcawl Local Board on Monday decided to light the streets with gas, in preference to electric lighting.

Liverpool Overhead Railway Company.—The traffic receipts of this railway for the week ending 14th inst. amounted to £665.

West India and Panama Telegraph Company.—The receipts for the two weeks ended January 15 were £233 less than for the corresponding period of 1893.

Accepted Tender.—The tender of Mr. H. Willcock, of Wolverhampton, at £4,985, has been accepted by the Wolverhampton Corporation for the erection of an electric light station.

St. James's and Pall Mall Electric Light Company.—The directors recommend a dividend at the rate of 4½ per cent. per annum on the ordinary shares for the year ending December 31, 1893.

Coventry.—The Town Council on Tuesday authorised the corporate seal to be affixed to an agreement between the Corporation, Mr. W. S. Graff Baker, and the Coventry Electric Tramways, Limited.

Wakefield.—The Town Council have refused the application of Mr. S. C. Gloyne for permission to lay a 2in. diameter iron pipe to carry an electric cable across Market-place from his shop to Mr. Winder's shop opposite.

Electric Exploitation Company, Limited.—This Company has been registered with a capital of £25,000 in £1 shares, to acquire certain patents relating to the generation and application of electricity, and to develop the same.

Radcliffe.—Mr. F. F. Bennett, M.I.E.E., of Messrs. Bennett and Druce, Preston, has been instructed by the Radcliffe local authorities to draw up a report and estimates, and recommend a system of electric lighting for that district.

Coatbridge.—The Town Council have referred to the Electric Light Committee a request from Mr. A. Paterson for permission to place an overhead wire between his two shops in Main-street, in connection with his installation of the electric light.

Tenders Required for Hanley.—Tenders are invited by the 29th inst. for the electric light wiring and fittings to the Corporation buildings. Specifications, plans, and particulars may be obtained from Mr. Joseph Lobley, borough engineer, Town Hall, Hanley.

Aberdeen.—The Gas Committee of the Town Council have settled the rates to be charged for electric meters. The charges will vary from 5s. to 30s. per quarter. It is expected that the meter that will be most commonly used will be the one on which the rate is 7s. 6d. per quarter.

Leamington.—The Town Council have decided to introduce telephonic communication between the office of the National Telephone Company and the police station at the old town hall. Specifications are to be prepared and advertisements issued for tenders to carry out the work.

Situations Vacant.—The Corporation of Wolverhampton invite, by the 27th inst., applications for the post of draughtsman and assistant in the borough electrical engineer's office, at a salary of £90 per annum; also for the post of working outdoor foreman and linesman, at a salary of £2 per week.

Ramsbottom.—The Electric Light Committee of the Local Board, having considered a scheme for supply of electric light for the district, and having regard to the necessity of obtaining a provisional order therefor, have adjourned the matter for further consideration. More information is to be sought.

City and South London Railway.—The receipts of the Company for the week ending January 14 were £951, against £1,008 for the same period last year, or a decrease of £57. The total receipts for the first half-year of 1894 show a decrease of £65 compared with those for the corresponding period of 1893.

Office-Lighting.—Messrs. E. P. Allam and Co., of 49, Finsbury-pavement, inform us they have recently completed the electric lighting of the extensive offices and sample-rooms of the Mazawattee Tea Company in Eastcheap, and are now engaged, among other work, in wiring 50, Bedford-square for Mr. A. Leveson.

Anglo-American Telegraph Company.—Balance dividends of 13s. 6d. per cent. on the ordinary stock and of £1. 7s. per cent. on the preferred stock are recommended by the Board, making total payments of £2. 11s. per cent. and £5. 2s. per cent. respectively for the year 1893. The sum of £844 remains to be carried over.

Eastern Telegraph Debentures.—The Eastern Telegraph Company notify that the coupons on their 5 per cent. debentures, due February 1 next, will be paid on and after that date at Messrs. Glyn, Mills, Currie, and Co.'s bank, 67, Lombard-street, E.C. Coupons should be left at the bank three clear days for examination.

Tenders Wanted for Cheltenham.—The Corporation invite tenders by the 23rd inst. for supplying and erecting engines, dynamos, and boilers at their electric light station. A copy of the specification and any further information may be obtained on application to Mr. Joseph Hall, A.M.I.C.E., Municipal Offices, Cheltenham.

Issue of Debentures.—Messrs. Robey and Co., Limited, announce the issue at par of £125,000 4½ per cent. first mortgage debentures, secured by a first mortgage on the freehold engineering works at Lincoln, and also forming a floating charge on all the other property of the company. Applications will be received by the Lincoln and Lindsey Bank, and Messrs. Prescott, Dimsdale, Cave, Tugwell, and Co. up to four o'clock this (Friday) afternoon.

Dover.—The Mayor mentioned at a meeting of the Town Council last week that the Electricity Supply Company hoped shortly to give an exhibition in the Town Hall. It would be necessary to carry wires into the hall, and it was suggested that they might as well be permanently fixed. It was decided to have

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the wires fixed permanently if the company would do the work, and wait till the electric light was adopted in the hall before making the charge.

Walsall.—The Town Council last week adopted the report of the General Purposes Committee, who recommended that the portion of the Wolverhampton-street Gasworks, shown on the plan prepared by the borough surveyor, should be appropriated as a site for the proposed electric generating station; and that the application of the Council for the sanction of the Local Government Board for a loan of £19,650 for the proposed scheme of electric lighting be increased to £22,000.

Canterbury.—The Town Clerk mentioned last week, at a meeting of the General Purposes Committee, that he was in a difficulty with regard to the electric light. As long ago as September he had the order to affix the Corporation seal, but he could not get the company to execute the deeds on their part. He had written time after time. Mr. Harris enquired whether the town clerk had got the transfer money. The Town Clerk replied that he only had £35 of it. The matter then dropped.

City and South London Railway Company.—The accounts for the past half-year show a balance, after providing for the debenture interest and the full dividend on the 5 per cent. preference shares, sufficient to allow the payment of a dividend on the consolidated ordinary stock at the rate of ⅝ per cent. per annum, against a dividend at the same rate for the corresponding period last year, leaving a balance of £1,064 to be carried forward to the next account, as against £822 for the same period last year.

Aluminium Company.—Mr. Justice Wright has made an order for the reduction of the capital of the Aluminium Company from £400,000 to £80,000. At the time the Company bought the patents under which they manufacture aluminium the cost of manufacture was 60s. a pound. These patents, it was said, were now useless, as other electrical discoveries had caused the same metal to be produced at 2s. 6d. a pound. The Company, having lost so large an amount of capital, passed a resolution reducing the £5 shares to £1, and it was this resolution Mr. Justice Wright has confirmed.

Keighley.—The Gas Committee of the Corporation have lately been making enquiries into the electric lighting system in operation at several places. The members, accompanied by the Mayor, have visited the House-to-House Company's electric lighting station in Leeds, and the Bradford Corporation's electric lighting station. The committee have also inspected a new patent boiler and furnace for producing steam from refuse, with a view to applying the steam to electric purposes. Arrangements have been made for visiting Morecambe and other places where different systems are in operation.

Peterborough.—Various private installations have been put up in this town, and now Messrs. Barford and Perkins, of the Queen-street Ironworks, have laid down an installation entirely by their own workmen, under the superintendence of Mr. J. Perkins, A.M.I.C.E. The motive power in this case is available from one of the steam-engines for driving other machinery in the works. The installation comprises a dynamo capable of an output of 50 amperes at 110 volts. The lights consist of incandescent lamps of 16 c.p. in the offices, and four large arc lights of 1,000 c.p. It is intended to instal additional arc and incandescent lamps in other parts of the works.

Direct Cable Company.—The report of the Direct United States Cable Company, Limited, for six months ended December 31 shows that the half-year's revenue, after deducting outpayments, amounted to £41,051, as compared with £43,629. The working and other expenses, including income tax, amounted to £19,059, leaving a net balance of £21,992, making, with £819 brought forward, £22,811. For the corresponding period of 1892 the working expenses and other payments amounted to £18,982. Interim dividends of 3s. 6d. per share for the quarter ended September 30, 1893 (paid October 24, 1893), and of 3s. per share for the quarter ended December 31, 1893 (payable January 24, 1894), have been declared, and the balance of £3,080 has been carried forward.

Accrington.—Mr. Riley moved, at a meeting of the Town Council, that a committee should be formed for the purpose of carrying out the electric light scheme, but it was pointed out that that was not the proper time to make such a resolution. Mr. Eli Higham said the matter had been in the hands of the Legal and Parliamentary Committee, but it had been very difficult to consider the subject. He certainly thought something should be done. If they intended to have the light for next winter for the centre of the town, they ought to take some steps, and Mr. Riley was quite justified in bringing the matter before the Council. If they did not intend to move in the matter, he thought they ought to let it be clearly understood, as he was quite sure outsiders would come in unless the Council did something. They were not doing justice to Mr. Shoolbred or the ratepayers.

Lighting at Aberdeen.—The Finance Committee on Monday laid before the Town Council a report by the city architect, superintendent of gasworks, and electrical engineer upon the cost of lighting the various departments of the municipal buildings. The installation, the report says, should be divided into four different departments: (1) The municipal department, consisting of 85 lights; (2) police and gas department, consisting of 32 lights; (3) sanitary department, consisting of 15 lights; (4) surveyor's department, consisting of 33 lights—a total of 165 lights. The cost of lighting the various departments, including fittings, is estimated as under: Municipal department, £145; gas and police department, £52; sanitary department, £27; surveyor's department, £46—a total cost of £270. The Council approved of the report, and authorised the electrical engineer (Mr. Murray) to prepare the requisite specification and invite tenders.

Taunton.—The Electric Lighting Committee of the Town Council last week reported that the borough surveyor and Mr. Couzens had been to London and had an interview with Dr. Fleming as to the proposed extension of the works. The committee said that owing to the burning out of an armature it was found necessary to procure one from Messrs. Laing, Wharton, and Down; their price was £55, and the committee recommended that it be purchased, and that the one which had broken down be repaired by Messrs. Newton. The committee stated that 33 small meters were required at once, and they had ordered that a sample meter be forwarded by Messrs. Laing, Wharton, and Down to Dr. Fleming, and if he approved thereof, that three dozen be ordered. The committee reported that there was not sufficient old wire in stock to carry the light to Osborne House, and they recommended that the wire be purchased. After some discussion the report was adopted.

Great Yarmouth.—The following tenders were received for the erection of electric lighting central station for the Corporation:

M. Barnard	£3,656 0 0
R. Eastoe	3,346 17 0
G. T. Flaxman	3,124 10 0
T. Howes	3,093 0 0
G. Beckett	2,858 10 0
Carter and Wright	2,817 0 0
F. Grimble	2,800 0 0
G. W. Beech	2,768 10 0
J. F. W. Bray	2,626 0 0
W. Cork	2,510 0 0
J. W. Rand	2,485 0 0

The tender of Mr. Rand having been withdrawn, that of Mr. Bray was accepted.

Electric Lighting in Edinburgh.—The sub-committee of the Edinburgh Town Council in charge of the matter of electric lighting in the city at a meeting this week, accepted an estimate for the removal of the buildings on the site of the proposed supply station to be erected at Torphichen-street, and generally approved of the plans for the station submitted by the burgh engineer. The plans show a building of considerable extent. Provision is made for the delivery of coal direct from the railway in the truck, and it is intended, when coal has to be stored, to run the wagons within the building, and by hydraulic machinery to hoist them to the level of the store and "tip" them over. In this way the work of delivery will be expeditiously overtaken. The engines and dynamos will be accommodated in the central part of the building facing Dewar-place, while on the same side of the station will be the plant for the arc lighting. As the matter is one of urgency, the Corporation requiring to be in a position to supply electric light to consumers in eight months' time, the work of clearing the site will be commenced at once.

Shoreditch.—The Dusting and Scavenging Committee of the Shoreditch Vestry have reported that, from the experience of other authorities, it appeared that dust refuse could be destroyed by fire at about £3,500 a year, and, in view of the saving that would thus be effected in this department, the committee felt that the time had arrived when a dust destructor should be provided. They therefore recommended the Vestry to take the necessary steps to provide for the destruction of dry refuse by a dust destructor. The report was adopted, and, in connection with this matter, a report from the Electric Light Committee was read from Messrs. Manlove, Alliott, and Co. on the question of the production of heat by dust destruction. The report showed that the annual saving from the present system, after crediting the value of steam sold for electric lighting purposes as a separate undertaking, would amount to £4,330 per annum. The committee reported that they had further considered the question of site, and were of opinion that the Pitfield site was the best for all these purposes. The price the committee proposed to offer was £33,500. The report was carried.

Barnet.—The Electric Light Committee of the Local Board reported last week that no tenders had been received in answer to advertisements for lighting the town, and that there was nothing before it to show that the electric light could be supplied to the town upon a satisfactory commercial basis. Mr. James said that although nobody had responded to the invitation to send in tenders, the committee ought not to quite close its efforts. The object of the Board in referring the question to the committee was to ascertain the best mode of lighting the town by electricity. He moved it be an instruction to the committee to further pursue its enquiries. Mr. Clark seconded the motion. Mr. Morse said the fact that a company had not come forward to undertake the scheme caused the committee to feel strongly that the companies did not regard Barnet as a favourable town for lighting. Personally, he was most anxious to have the electric light if it could be obtained at a reasonable cost. What he would suggest was that the Board should empower the committee to spend about £10 in getting from a good man a report as to whether it was advisable to have electricity in the town. The motion, with the addition of Mr. Morse's suggestion, was adopted.

Tenders Required for Edinburgh.—The Corporation invite tenders for the following work in connection with their electric lighting station in Torphichen-street, Edinburgh: Contract No. 1. Boilers (dryback marine type) and mechanical stokers. No. 2. Engines (Willans), dynamos, pipes, etc. No. 3. Switchboard instruments and connections. No. 4. Storage batteries. In contract No. 2 it is a condition that the dynamo-makers must have already constructed dynamos of at least 100 units capacity. Copies of any of the specifications can be obtained on written application

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from the Town Clerk. All information will be supplied by Prof. A. B. W. Kennedy, 14, Old Queen-street, Westminster, S.W. Firms wishing to obtain copies of any of the specifications must send with their written application a deposit of two guineas for one specification, or three guineas for any larger number; the deposit will be returned on receipt of *bonâ fide* tenders. Tenders are to be directed to the Town Clerk, and enclosed separately in sealed envelopes, marked "Electric Lighting—Tender for Contract No. —." Tenders will only be considered from firms who are actually manufacturers of the whole or an important part of the work for which they estimate. They must be received in Edinburgh not later than Tuesday, the 30th inst.

The Newport Tenders.—"Motor," writing to a Cardiff paper on this subject, says: "Before committing the Council to an outlay of £2,595 more than the lowest tender, every detail should be rigorously exhausted and the figures fully analysed. Take the two reasons assigned for accepting the higher tender: 1. 'The committee have visited works done by Messrs. Fowler and Co.' Have they visited any works done by Messrs. Crompton and Co.? 2. The engineer stated that 'Messrs. Crompton and Co. have carried out works on the low-tension system.' Does this disqualify them for the high-tension system? If Messrs. Crompton and Co. are capable and competent to carry out the works in accordance with the Council's requirements, and willing to comply with the provisions and conditions stipulated for the installation, why should not the town benefit to the extent of the difference in the two tenders—£2,595? It might appear from the engineer's explanation that it is a choice between two systems. In that case the Council could not do better than adopt the best, even at the first cost of greater capital outlay; but if it is not a choice of systems, but of one out of two competent contractors, and if both are prepared to adhere to the prescribed conditions and terms and willing to undertake the work in accordance with the specification (and there ought to be no difficulty in ascertaining this), the committee would not then hesitate to recommend the acceptance of the lowest of the two tenders and, in addition to the saving of £2,595, secure the advantage of a large portion of the contract sum being circulated amongst the working population by the machinery being made at Newport, as it appears would be the case if Messrs. Crompton and Co. secured the contract."

The Manchester Edison-Swan Company's Showrooms.—The showrooms which the Manchester Edison-Swan Company, well known in that city in connection with electric lighting, have recently built, are very interesting and attractive. To the passer-by only one of the showrooms is visible, and the impression given is that this is the full extent of the premises. But let the visitor enter, and surprises will be in store for him. He is led down, apparently to the bowels of the earth, but instead of arriving at vaults he enters a sort of Aladdin's palace, brilliant with electric light. Besides the ordinary showrooms the Company have fitted up a complete suit of model rooms, beautifully furnished, and arranged with every variety of style of electric light fitting. The object of this is that their clients may see the actual effect the fittings they are selecting will have in private rooms. A special feature is made of electroliers of cut crystal glass and gilt metal-work, most tastefully arranged—a combination which seems perfectly suited to show the electric light to full advantage. Among a number of beautiful designs in this style is a large electrolier, the general lines of which follow the curves taken by water falling from a fountain, the sparkling crystal lending itself very happily to this effect. Besides the drawing, dining rooms, etc., there is a large and handsome billiard-room with a new arrangement for lighting the table, which is a distinct improvement on the old style. Those visitors who take an interest in the engineering part of electric lighting are given an opportunity of examining the generating plant which produces the current needed for the different showrooms, both gas and steam power being employed. Thus those who think of having the light installed in their country houses can see both systems at work, and judge for themselves which would be the more suitable for their purpose. Taken altogether, the show is a very fine one, and those near Manchester thinking of fitting up their houses would find it advantageous to make an inspection of these showrooms before doing so.

Lighting at Aberdare.—The Local Board have this week considered an application to assent to the provisional order sought by Messrs. Gery and Rhys, on behalf of Messrs. J. C. Howell and Co., for the lighting of a portion of the town. The Chairman pointed out that the company only sought for power to light Canon-street, a portion of High-street, Commercial-place, Commercial-street, Cross-street, and Cardiff-street at present, and that the whole of their power only extended to half a mile from St. Elvan's Church. He also noticed they asked for power to charge 8d. per unit, while in Pontypool they only charged 6d. per unit. Mr. P. T. Rhys, solicitor to the promoters, and Mr. J. C. Howell, one of the directors of Messrs. J. C. Howell and Co., were admitted into the room, and, in answer to the questions of the chairman, said the only reason why the application was made in their name was that they had no time to form a local company, but that they intended to form a local company as soon as possible. He also explained that the 8d. per unit was a maximum charge, and no doubt they would reduce this. There was power in the provisional order to transfer the powers to a company when formed. Mr. D. P. Davies said he thought the order sought for was very objectionable. It was not a local company, and its charges were too high. Another and a very strong objection was that it only provided for a very small portion of the town. He would therefore move that the Board should refuse to grant its assent. The chairman said he feared as Mr. Davis was a shareholder in the gas company he was disqualified to to vote, and the clerk said he thought it was so. Mr. R. Llewellyn moved, and Mr. W. Little seconded, that the Board should assent. The Chairman said he would have to vote against that on the ground that the order asked for was so limited. Had they asked for power to light Aberaman and Trecynon as well as the town he would probably support it; but he felt the present proposal would only keep back a far better scheme. A division being taken, four voted in favour of assent being granted and two against.

Lighting of Windsor.—At a meeting of the Town Council last week, a letter from Messrs. C. A. Parsons and Co., the Fowler-Waring Cables Company, and Mr. A. A. C. Swinton, to the following effect was read: "You are perhaps aware that negotiations are in progress between the liquidator of the Windsor and Eton Electric Light Company, Limited, and ourselves, with the object of our making the necessary arrangements for enabling the company to resume its business in a manner which will be satisfactory to the local authority and the public. We therefore beg to inform you that we propose to lay down a central station in Windsor, with entirely new plant, for the supply of 10 000 8-c.p. lamps, the generating plant to be manufactured by Messrs. C. A. Parsons and Co., of Heaton Works, Newcastle-on-Tyne, and to be similar to those supplied by the supply companies at Newcastle-on-Tyne, Scarborough, and Cambridge, where they are in very successful operation. The mains to be supplied by the Fowler-Waring Cables Company, and to be similar to those supplied by them to the London Electric Lighting Company, Limited, the City of London Electric Lighting Company, Limited, and the Corporations of Exeter, Brighton, etc. The system to be the high-tension alternating at 2,000 volts, transforming into 100 volts before reaching the consumers' terminals. We would propose to sell or dispose of the present central-station site, and to apply to your Corporation for the sale or a lease of land and water power on the Corporation property at the waterworks. We believe that the contemplated arrangements would involve an expenditure of £15,000, and that the light could be supplied within six months from the date of an order of the court allowing the company to resume its business. We shall be much obliged if you will bring this letter before the Electric Lighting Committee at their next meeting, and we shall be pleased to attend that or any subsequent meeting to give further explanation that may be required." The Deputy Town Clerk said the letter had been laid before the Waterworks Committee, who had directed the town clerk to write to the Board of Trade to ascertain the position of the late electric light company. He had received a reply stating that the order had not been revoked, and that it did not appear to contain any provision for the transfer of the powers, duties, and obligations of the undertakers to any other company or person. The Deputy Town Clerk, continuing, said some communications were made to the Mayor, who made arrangements for the gentlemen to meet the Waterworks Committee, which they did. It appeared from what was said that the present works were wholly useless, and it would be necessary for new wires to be laid down altogether. The Mayor suggested that the matter be referred to a committee, which would be composed of those members who were not interested in either electricity or gas. Councillor Soundy moved that such a committee be formed, and this was agreed to.

Fleetwood.—The clerk to the Improvement Commissioners has been authorised to advertise for applications for the position of resident working electrical engineer in connection with the electric lighting station. A public meeting of ratepayers, convened by the chairman of the Commissioners (Mr. J. F. Marginson), to consider the proposal to light the town by electricity was held at the Free Library last week. Mr. Marginson presided, and most of the members of the Commissioners occupied seats on the platform, together with Mr. J. Tildsley (the clerk and accountant) and Mr. Dawbarn (the representative of the Brush Electrical Engineering Company, whose tender had been accepted). Mr. D. W. Dickinson moved a resolution approving of the action of the Commissioners with reference to the proposed installation of electric lighting. Mr. J. Smyth seconded. Mr. Dawbarn, who was asked to explain the electric light scheme, pointed out to pause further, as Mr. Drewry suggested, would be a serious step, as they had had their provisional order renewed four times. If the order was not again renewed, the effect would be that any enterprising company might succeed in establishing works at Fleetwood, and the Board of Trade would say that in common fairness they must let the private enterprise take its course. At Fleetwood they had one exceptional advantage, and that was they would not be called upon to take the electric light as a luxury, but they would be able to save a considerable sum per annum as compared with their present gas bill. He had prepared an estimate of the working cost with the present plant. The expenses for maintaining the present plant, assuming it would maintain the 232 street lamps of 32 c.p., and 5,900 incandescent lamps of 8 c.p. in private houses, works, etc., for material, fuel, lamp renewals, salary of the engineer, wages of his staff, etc., amounted to £966. 11s. To this they had added £100 for incidentals. They had also added for the machinery, the conductors in the streets, and the whole apparatus, including the station buildings. That sum amounted to £503, bringing the total to £1,570. There was then the interest on the capital outlay, and the setting aside of a sufficient sum to liquidate that outlay in a term of years. For this he had taken £600, bringing the total expenditure per annum to £2,170. The question had been asked, What would be the cost of street-lighting? They were now lighting 200 street lamps at a cost of £270 per annum. These lamps are only 8 c.p. each, and the result was their streets were really badly lighted, and did not

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compare favourably with any town of the same size. They could not expect to get 32-c.p. lamps and 15 per cent. more of them, with 10 per cent. longer time of burning, for the same money, but they would agree the sum of £371. 18s was an exceedingly good result for such a vast increase. The second item of the revenue would be from private consumers. He was not in a position to pledge the Board, and he did not know whether they would finally adopt the figure he had assumed, but he thought they would view favourably the proposal to charge 12s. per lamp of 8 c.p. per annum. That would bring in a revenue, for 5,900 lamps installed, of £3,540, which, added to the public lighting, amounted to £3,911. 18s. The total expenses, including interest, amounted to £2,170, leaving £1,740 as natural profit, which would doubtless go towards further reduction—either by giving the street-lighting free or still further reducing the cost to the private consumers. He believed the Board would be quite willing to charge by meter at 6d. or 7d. per unit. That corresponded to gas at something like 3s. 6d. per 1,000. At 4s. per 1,000 a 10-candle gas lamp would cost £1 for every 1,000 hours burning, whilst electricity at 6d. per unit, for the same light and the same time would cost 15s. To the latter must be added the cost of lamp renewals. They lasted about 1,000 hours, and cost about 1s. 6d., so that the total would be 16s. 6d. against £1. The Commissioners fully believed 12s. per lamp was lower than that basis. In London the cost of putting the light in offices was as low as £1. If the Commissioners kept that work in their own hands they would be in a position to give low prices, because they would not want profit. He thought they would be able to instal lights in private houses at about £1, and in shops at 17s. or 18s. After some discussion the resolution was put to the meeting and carried.

PROVISIONAL PATENTS, 1894.

JANUARY 8.

382. **Improvements in secondary batteries.** Henry Capel Lofft Holden, The Eves, Belvedere, Kent.

433. **An improved electric switch.** Chaimsonovitz Prosper Elieson, 4, South-street, Finsbury, London.

439. **Improvements in girder clamps and hangers for supporting pipes, electric conductors, and the like.** Henry Harris Lake, 45, Southampton-buildings, Chancery-lane, London. (Charles MacTaggart and Francis McKernan, United States.)

JANUARY 9.

444. **Improvements in electric light fittings.** Charles Spencer Northcote and John Benjamin Verity, Plume Works, Aston, Birmingham.

454. **Improvements in the generation and distribution of the electric current.** William Ealdred, 5, Brightside-bank, Brightside, Sheffield.

455. **Improvements in incandescent lamp shades.** Edward Dean Cook, 70, Wellington-street, Glasgow. (Complete specification.)

484. **Improvements in electrical alarum clocks.** Joseph Coshigan, 97, Newgate-street, London.

489. **Improvements in electrical clocks.** Ernest Herbert, 11, Southampton-buildings, Chancery-lane, London.

493. **Improvements in safety cut-outs specially applicable for trolley wires of overhead electric railways.** Alfred Julius Boult, 325, High Holborn, London. (Melancthon Hanford, United States.)

494. **Improvements in forges or furnaces for heating or working metals electrically.** William Phillips Thompson, 6, Lord-street, Liverpool. Charles Lewis Coffin, United States.) (Complete specification.)

495. **Improvements in transformers or converters for electric currents.** William Phillips Thompson, 6, Lord-street, Liverpool. (Charles Lewis Coffin, United States.) (Complete specification.)

496. **Improvements in apparatus for heating or welding metals electrically.** William Phillips Thompson, 6, Lord-street, Liverpool. (Charles Lewis Coffin, United States.) (Complete specification.)

513. **Improvements in or relating to apparatus for the production and distribution of electricity.** George Joseph Philpott and Robert Hammond, 46, Lincoln's-inn-fields, London.

524. **Automatic switch for accumulator charging.** Robert William Peacock Robertson, Charing Cross, London.

JANUARY 10.

526. **Improvements in electric brushes.** Edward Lewis Levetus, 7, Cherry-street, Birmingham.

546. **Improvements in electric telephony.** Alexander Muirhead and George William Green, 124, Chancery-lane, London.

548. **Improvements in or appertaining to working quadruplex and duplex telegraph signal-receiving instruments.** William Phillips Thompson, 6, Lord-street, Liverpool. (William Francis Melhuish, India.)

JANUARY 11.

646. **Improvements in primary voltaic batteries.** William Walker, jun., Frank Richard Wilkins, and Jabez Lones, 7, Staple-inn, London.

660. **Improvements in guards for electric and other lamps.** James Eaton-Shore, 77, Chancery-lane, London.

653. **Improved means for arranging and intensifying the magnetic fields of dynamo-electric machinery.** James William Thomas Cadett, 33, Southampton-buildings, Chancery-lane, London.

654. **Improvements in electrically-illuminated advertising signs.** Guy Carey Fricker, 15, Spencer-road, Putney, London.

666. **Improvements in holders for incandescent electric lamps.** John Birnie Clayton Evans, 4, South-street, Finsbury, London.

669. **Improvements in electric batteries.** Charlton James Wollaston, 47, Lincoln's-inn-fields, London.

670. **Improvements in the manufacture of electrodes and use of the same.** Arnold Philip, 43, Onslow-road, Richmond, Surrey.

JANUARY 12.

689. **Improvements in the application of incandescent lamps for use as nightlights** Alexander William Stewart, The Crescent, Dalmuir, Dumbartonshire.

690. **Improvements in electric apparatus for signalling on railways.** Robert Stuart Hampson, 17, St. Ann's-square, Manchester.

722. **Improved electrical marine engine governor.** George Leonard Addenbrooke, 433, Strand, London. (R. Macdonald, Australia.)

764. **Improvements in jointing and connecting electric cables.** George Hinde Nisbett, 248, Stanstead-road, Forest Hill, London.

JANUARY 13.

791. **A combination door-bolt and electric switch.** John Joseph Wilson, 21, Croydon-grove, Croydon.

835. **Improvements in the construction of electrolytic apparatus, and in the application thereof in oxidising, chlorinating, and analogous processes.** James Hargreaves and Thomas Bird, 191, Fleet-street, London.

836. **Improved means for obtaining metallic bases and their compounds by electrolysis.** James Hargreaves and Thomas Bird, 191, Fleet-street, London.

SPECIFICATIONS PUBLISHED.

1889.

1480. **Electric meters and motors.** Alderton. (Second edition.)

7719. **Electric or galvanic elements or cells.** Schoop. (Second edition.)

19554. **Alternating-current generators, etc.** Von Dolivo-Dobrowolsky and others. (Second edition.)

1892.

23101B. **Galvanic batteries.** C. A. J. H. and H. E. R. Schroeder.

23773. **Electric smelting.** Niewerth.

1893.

562. **Electric measuring instruments.** Goolden and Evershed.

933. **Electrical arc lamps.** Lauder.

1574. **Tapping incandescent lamp circuits.** Fell. (Vetter.)

2199. **Measuring electric currents.** Baron Kelvin.

2241. **Galvanic battery.** C. A. J. H. and H. E. R. Schroeder.

3412. **Transmitting telegraphic signals.** Muirhead and Saunders.

3734. **Secondary battery plates.** Hough and March.

3743. **Carbon electrodes.** Liveing.

3744. **Carbon electrodes.** Liveing.

3757. **Thermo-dynamic motors.** Brown.

3833. **Electric connections.** Lloyd.

4077. **Electrical measuring instruments.** Holden.

4580. **Telegraphic apparatus.** Tyer.

13448. **Electricity meters.** Aschner.

16000. **Telegraphy.** Allison. (Wicks.)

20046. **Electric selecting-devices.** Bogart and others.

21592. **Electric switches.** Reid.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	2⅜
— Pref.	—	2¼
Charing Cross and Strand	—	5
City of London	—	11½
— Pref.	—	13½
Electric Construction	—	1⅜
House-to-House	5	2
India Rubber, Gutta Percha & Telegraph Co.	10	22½
Liverpool Electric Supply	5	6½
	3½	4⅝
London Electric Supply	5	1
Metropolitan Electric Supply	—	8 5/16
National Telephone	5	4⅜
St. James', Pref.	—	8½
Swan United	3½	3⅝
Westminster Electric	—	5½

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NOTES.

Acton. — The question of extending the telephone system to Acton is under consideration.

Skates.—A German electrician is reported to have adapted the incandescent lamp to the points of skates.

Folkestone.—The Town Council will further consider the report of the Electric Light Committee on the 13th proximo.

Newcastle.—As in other towns, so in Newcastle is the use of the electric light causing an increase in the consumption of gas.

Clock-Lighting.—It is suggested that the clock in the turret of the new Yorkshire Penny Bank at Bradford should be lighted by electricity.

Shiplighting.—The "Berlin" and the "Amsterdam," recently launched at Hull for the Great Eastern Railway Company, are to be lighted by electricity.

Conversazione.—The annual soirée and conversazione of the Bradford Scientific Association took place on Tuesday evening in the society's rooms, Sunbridge-road.

Condensing Plant.—Messrs. W. H. Allen and Co., of Lambeth, S.E., have forwarded us a copy of their illustrated catalogue of condensing plant suitable for electric light installations.

Telephony.—The Gas Committee of the Leeds Corporation have decided to have telephonic communication established with the different gasworks through the central telephonic exchange.

The Working of the Telegraph System.—The commission from St. Martin's-le-Grand appointed to enquire into the working of the telegraphs over the country, has this week visited Glasgow.

Tunbridge Wells.—The Local Government Board have sanctioned the application made by the Tunbridge Wells Corporation to spend £13,000 on electric lighting in the principal streets of that town.

The Taunton Case.—Mr. H. E. Hunt, until recently manager and engineer of the Taunton electric light works, has been sentenced to 12 months' imprisonment for forging two promissory notes for about £300.

The Patent Office.—A new series of illustrated abridgment classes will shortly be issued by the Patent Office. Abridgments have been completed referring to specifications for the period 1877-1883.

Electric Traction on Railways.—An electric locomotive has been tried on the railway between Havre and Paris. It was attached to a train of 13 carriages, and is said to have attained a speed of 75 miles an hour.

Dr. Tibbits's Action.—In the action brought by Dr. Herbert Tibbits to recover damages for an alleged libel published in the *Charity Record*, the jury returned a verdict for the defendant, and judgment was accordingly given to that effect.

Personal.—We understand that Mr. W. B. Esson will join the well-known firm of Messrs. Johnson and Phillips, Charlton, on February 1 as manager of the electric light, electric transmission of power, and electro-chemical departments.

The Leeds Tramways.—The Leeds town clerk has received a communication from the Board of Trade, who sanction the borrowing by the Corporation of £130,000 for the purchase of the undertaking of the Leeds Tramways Company under the provisions of the Tramways Act.

New French Cable.—A new French submarine cable is about to be laid in the Red Sea. It crosses the Bay of Jibuteel, placing Obock in communication with Jibuteel (or Djiboutil), which is to be the new seat of government of the French colony. The cable is 31½ nautical miles in length.

Transmission of Power in Russia.—A German syndicate is stated, by a telegraphic news agency, to have secured a concession from the Russian Government for the erection of gigantic electric power works for the purpose of transmitting electrical energy from the famous Imatra waterfalls in Finland to St. Petersburg.

The "Medical Battery" Company, Limited.—On Monday the hearing was resumed at the Marlborough-street Police Court of the charges of conspiracy to defraud brought against Messrs. C. B. Harness, J. M. McCully, and C. B. Hollier, in connection with the "Medical Battery" Company. The case was again adjourned.

The Board of Trade and High Pressure.—The President of the Board of Trade (Mr. A. J. Mundella) having had his attention called by Mr. Weir, M.P., to a recently published letter from Mr. James Keith, C.E., on the dangers of high-voltage electricity, has replied that the matter is receiving the Board's consideration.

Engineers and Shipbuilders.—A special general meeting of the North-East Coast Institution of Engineers and Shipbuilders will be held on Tuesday in the Physical Lecture Hall of the Durham College of Science, Newcastle-upon-Tyne. The discussion of Mr. J. R. Fothergill's paper, "On Mercantile Marine Engineers," will be resumed.

The Financing of Electrical Enterprises.—A telegram from Berlin states that Dr. Rosenthal, of Messrs. Siemens and Halske, and Mr. von Koenen are about to establish a banking business in Berlin. This establishment, in which Messrs. Siemens and Halske will be sleeping partners, will mainly direct its operations towards the financing of the electrical undertakings of the latter firm.

The Newport Tenders.—The Parliamentary and Improvement Committee of the Newport Corporation on Tuesday again considered the question of lighting the town by electricity. After a protracted discussion nothing definite was arrived at, but the members of the committee agreed to accept an offer made by Messrs. Crompton to inspect their work at Chelmsford before deciding upon a tender, and also to inspect a London central station.

The Potential of the Atmosphere.—M. André, the French professor who was injured some time ago in a balloon accident while taking atmospheric observations, has published a report of what he was trying to do. The experiments to determine the difference of electrical potential at different altitudes resulted in showing that in fine weather, when the electrical conditions are undisturbed, the strength of the electrical field remains unaltered however far it is tested along a vertical line.

The Gas Explosions in the City.—A report from Mr. W. H. Preece on the subject of the recent explosions on Ludgate-hill in two manholes was read before the City Commission of Sewers on Tuesday. Mr. Preece stated that the explosions were due to a collection of coal-gas and air in the boxes, but that the cause of ignition was not apparent. Since the occurrence the electric lighting company have introduced a system of inspection of such manholes so as to prevent a collection of gas in the manholes from leaky gas-mains.

Traction in New Zealand.—Dealing with the subject of electricity as a motive power on tramways, a Hobart paper concludes a leading article to objections raised by the

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New Zealand Government as follows: "It may be hoped that the working of the Hobart system, which proves that all the dreaded difficulties of running the telephones and tram service side by side have vanished—mere chimeras evolved from nervous imaginings—will convince the chief of the New Zealand Telegraph Department that he can very safely leave the Dunedin Tramway Company to their own devices."

Society of Arts.—The second Cantor lecture by Prof. F. Clowes, D.Sc., on "The Detection and Measurement of Inflammable Gas and Vapour in the Air," will be delivered on Monday. It will deal with attempts to utilise diffusion and other physical processes, Liveing's electrical indicator, apparatus depending upon the alteration of volume caused by burning the gas, and apparatus depending on the measurement of volume of gas required to bring the mixture to the ignition point. On Tuesday, at 8 p.m., in the Applied Art Section, a paper on "The Adam Architecture in London," by Mr. Percy Fitzgerald, M.A., will be read.

The Dynamo-Electric Machine. — On Tuesday, before the Manchester Literary and Philosophical Society, Mr. Henry Wilde, F.R.S., gave a brief history of the dynamo-electric machine, and an account of his discoveries. He also gave experimental illustrations by means of the installation which he has presented to the society of the uses to which the supply may be put in philosophical research. Special interest was manifested by Mr. Wilde's exhibition of the new line which he has observed in the spectrum of thallium, and in experiments with his magnetarium to illustrate his theory of terrestrial magnetism.

Netherland Society for the Promotion of Industry.—As mentioned in a previous issue, this society desires to receive papers containing an indication of the means to obtain energy through windmills, to accumulate this energy electrically, to transmit it or to make it transportable, and more particularly an answer to certain questions given in a former issue is required. The prize offered is the gold medal of the society and a reward of £30. Answers must be sent before July 1, with the author's name in a closed envelope, to the general secretary of the society, Mr. F. W. van Eeden, at Haarlem, Holland.

Gas and Electric Light.—A meeting of inhabitants of Notting Hill and North Kensington has passed a resolution expressing the opinion that a parliamentary committee should be appointed to enquire into the present condition of the gas supply of London, with a view to legislation in the direction of securing a reduced and uniform rate of charge, the free use of meters, and a further diminution in the statutory rate of dividend. Mr. Rowlands, M.P., mentioned at the meeting that he was in favour of the municipalisation of the supply, but they had to see how far the electric light was going before they talked about purchasing the goodwill of the companies.

Underground Electric Railways in Paris.—It is reported that the French Chamber of Deputies will shortly be called upon to discuss the question of constructing a series of underground electric railways. A concession was granted by the Municipal Council over a year ago, but so far the consent of Parliament has not been given. The proposed line will run from the Porte Dauphine of the Bois de Boulogne, and thence under the Avenue Victor Hugo to the Arc de Triomphe, along the Champs Elysées to the Place de la Concorde, Rue de Rivoli, Place de la Bastille, Boulevarde Diderot, and then on to Vincennes—altogether nearly 10 miles, with 17 stations *en route*.

Electric Lighting of St. Paul's.—If the experiment about to be tried in St. Paul's Cathedral on a large scale is satisfactory, it is said that plant for generating the current will be put down in the crypt; but for the present the current will be drawn from the mains of the City of London Company. It is proposed to place 14 arc lamps in the dome, eight of them in the Whispering Gallery, and four in the quarter galleries, but the problem is how to find positions which shall not make the globes conspicuous in daylight. On a lower level, incandescent lamps will be arranged, and to the columns clusters will be attached on the east side, so that they will be invisible to worshippers who sit facing the communion table. The details have still to be settled.

The Waterloo and City Railway.—When the Waterloo and City Railway is in a position to begin tunnelling from the Royal Exchange to Waterloo, it will according to the *Financial News*, appeal for capital under favourable conditions; for at the forthcoming meeting of the London and South-Western Railway the shareholders are to be asked to pass resolutions sanctioning arrangements to guarantee the Waterloo and City capital, and to operate the electric line when completed. This is not to be wondered at; for the Waterloo and City Railway, remarks the same paper, is designed wholly as a feeder to the South-Western, and will, no doubt, get all the volume of traffic which passes over the South-Eastern from Cannon-street to Waterloo Junction daily, besides further popularising the south-western suburbs among City men.

Charges for Current in Leeds.—The Yorkshire House-to-House Electricity Company, of Leeds, state that the increasing demand for electrical energy has resulted in an extension of the works being decided upon, and at the same time a reduction in price will be made, commencing in April, when the charge per Board of Trade unit will be as follows: When the consumption for the quarter does not exceed 1,000 units, 7d.; exceeding 1,000 and not exceeding 1,500 units, 6¾d.; exceeding 1,500 and not exceeding 2,000 units, 6½d.; exceeding 2,000 and not exceeding 2,500 units, 6¼d.; exceeding 2,500 units, 6d. These prices will be subject to discount based upon the number of hours per quarter during which the current is used, each customer being called upon to declare the maximum number of lights required to be in use at any one time.

Arc Lamp for Lantern Exhibition.—The Leeds Photographic Society introduced a novelty at their annual lantern exhibition in the form of an improved lamp for projecting the slides on to a 22ft. screen. In past years various types of burners have been used—the blow-through jet, mixing jet, calcium, and saturator—all of which are good in their way, but this year the greatest improvement attempted was carried out, and electricity has taken the first place, and showed its infinite superiority to all forms of limelight. No gas-cylinder bursting was to be feared, and no hissing or cracked condensers took place to interfere with the exhibition, but a clear, steady, white light which showed up the slides to their best advantage. The lamp is the design of Mr. Borland, of Leeds, is self-regulating, and of constant focus, fitting on to the ordinary tray in any lantern, and occupies about the same space as a blow-through or mixing jet.

The Northern Society of Electrical Engineers.—The inaugural dinner of this society took place in Manchester on Monday. In the unavoidable absence of the president, Dr. John Hopkinson, F.R.S., Mr. Henry Edmunds, one of the vice-presidents, occupied the chair. He was supported by Messrs. G. E. Preece and W. P. J. Fawcus, vice-presidents, and the following members of the council: Dr. Edward Hopkinson, Messrs. J. Vincent Swindells, A. Eckstein, G. W. Lowcock, E. A. Claremont, Alex. Marr, J. H. Rider, J. Taylor, C. S. Northcote, Mr. Geo. J. Somerville, hon. treasurer, Mr. John Darney, hon.

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secretary, and upwards of 50 members. After the toast of "Queen and Royal Family," Mr. G. E. Preece proposed "The Society" in a speech recapitulating its rise and progress from its inception. Other toasts were proposed and responded to by Messrs. E. Manville, W. P. J. Fawcus, S. Z. de Ferranti, and Dr. Edward Hopkinson. A musical programme which followed was much appreciated.

The Municipalisation of Tramways.—On Monday Justices Mathew and Collins gave judgment in the case of the London Tramway Company *v.* the London County Council. The Council had given notice under the Tramway Act to acquire a section of the company's system in Kentish Town, and Sir F. Bramwell was appointed by the Board of Trade as referee to determine the compensation due to the company. He awarded £64,500, but refused evidence of the annual rental on the ground that it would involve an allowance for past and future profit which the Act excluded. He based his award on the cost of the construction, less depreciation, whereas the company claimed 20 years' purchase of the annual value. Justice Mathew said he concluded that Parliament never intended such consequences to the company as were insisted on by the Council, and the award must be remitted to an arbitrator to deal with the question of valuation. Justice Collins concurred, and the award was accordingly sent back to Sir F. Bramwell for alteration of the amount. The County Council have decided to appeal against this verdict.

Electric Transmission of Power in Sweden.—An important installation of this nature was recently opened at Gringesberg, Sweden. The waterfall which supplies the power, says *Engineering*, is situated at a distance of some seven or eight miles from the mines. The Hallsjö waterfall has a height of 150ft., and the water is conveyed through a pipe of some 1,700ft. in length to the turbine-house, where there are four turbines of 100 h.p. each, and a smaller turbine of 20 h.p. Each turbine works a dynamo; the current is transformed from 100 volts to 5,000 volts, and conveyed to the Gringesberg and Björneberg mines through copper wires, 3mm. to 4mm. thick, attached to high poles. At the place of consumption the current is again reduced to 100 volts. At Björneberg there are installed an electric motor of 30 h.p. and 20 incandescent lamps, and at Gringesberg four motors of an aggregate of 110 h.p., 20 arc lamps, and 200 incandescent lamps. The power was previously supplied by several steam-engines and smaller local turbines, all of which sources have now been entirely dispensed with.

Lighting in Liverpool.—Before the Liverpool Engineering Society last week Mr. A. B. Holmes read a paper on the "Supply of Electrical Energy: Its Cost and Price." In the course of his remarks the author recorded the progress made since the year 1890 by the Liverpool Electric Supply Company. Since that date the length of street mains had been increased from 20 to 30 miles, and the number of lamps supplied from 12,000 to 25,000. The items which form the cost of production were dealt with seriatim, and attention was drawn to directions in which with an increased output economies in working may be attained. The load on a station supplying electricity for lighting purposes was shown to be extremely variable, the maximum load in winter being many times greater than the minimum load in summer, the cost of working the plant being much greater in consequence than would be the case were it possible to run the plant under uniform load. It was pointed out that great advantage would be derived from any practicable method of storage, but that the high cost of accumulators at present prevents their commercial use for that purpose.

A Sensation in Incandescent Lamps.—"The Star Electric Lamp Company," says a correspondent of the *Electrical World*, "has now on public exhibition on Michigan-avenue, Chicago, Ill., three incandescent lamps that are creating quite a sensation in electrical circles. In appearance they are ordinary 16-c.p. lamps, but it is claimed that by actual measurement one of them gave 720 effective candle-power, another 184, and the other 160. The light is perfectly white and steady, while the filament seems scarcely larger than in the ordinary lamp. The lamps were connected directly to the Edison mains, and the instruments showed that the lamps were burned at 111 volts. The amperes averaged, it is claimed by those present, one eighth ampere per lamp. Inventor John Kammer stated that these unusual results were obtained by introducing into the bulb a peculiar vapour which he recently discovered. The difference in illuminating power is determined by the quantity of vapour in the bulb. Mr. Kammer's efforts are now being directed to perfecting a one-watt lamp, and from the results already secured with his vapour treatment he expects to place such a lamp on the market in a very short time."

Cause of Electric Currents Observed in Plants. Mr. O. Haacke, in the *Ann. Agron*, deals with this subject. He states that, according to Künckel, electric currents in plants are due to the movements of water in the tissues, and not to differences of potential, existing independently. The author considered it probable that vegetable electricity was due to biological processes, especially respiration and the consequent chemical changes. He experimented with leaves and flowers of dicotyledons and on a large mushroom in an atmosphere of hydrogen. The electric current was diminished, but never quite suppressed, owing, probably, to intramolecular respiration. On readmitting air, the electric current revives. Young bean plants behaved differently, the current being increased in an atmosphere of hydrogen. This is explained by the known fact that beans are distinguished by a very high intramolecular respiration. Flowers, and especially stamens and pistils, show very decided oscillations under the influence of electric currents. It is not possible to state exactly in what manner respiration gives rise to electric currents without a knowledge of successive chemical changes which take place during respiration. The results of the author's experiments seem to indicate that vegetable electricity is not exclusively due to filtration of water.

Electrolytic Estimations and Separations.—In a paper in the *Monatsh*, Mr. G. Vortmann describes the behaviour on electrolysis of salts of zinc, iron, cobalt, and nickel, to which solutions of an alkaline tartrate and an alkaline hydroxide have been previously added. Of these metals, the three first named may be quantitatively deposited from the alkaline solution; whilst, under the same conditions, the last named remains in solution, thus affording a method for the separation of nickel from zinc, iron, and cobalt. Iron may be separated from zinc in alkaline tartrate solution by employing a cathode of platinum, whereby the iron is deposited with only a trace of zinc. By dissolving and redepositing two or three times, the iron is obtained entirely free from zinc. To estimate zinc in presence of iron, potassium cyanide is first added to the solution, whereby the iron is converted into potassium ferrocyanide; sodium hydroxide is then added and the current passed, when the zinc is deposited, the iron remaining in solution. The author further describes a method of estimating cobalt, nickel, and copper when present with much iron. A solution of the metal, in which the iron is present as a ferric salt, is placed in a platinum dish and treated with excess of ammonia,

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and the current passed, whereupon, without the necessity of filtering off the ferric hydroxide, cobalt, nickel, and copper are thrown down on the cathode in a well-adhering mass. In the separation of copper and iron, the latter metal is best oxidised with nitric acid.

Lighting of the City.—Mr. Bridgman, the retiring chairman of the Commission of Sewers, gave on Tuesday a review of the past year's work. Referring to the electric light, he stated that there were now 479 electric arc lamps in use, costing £26 each, or £12,454 per annum. Experiments had been made in Aldermanbury and Basinghall-street with incandescent lamps, with a view to determine the most desirable method of lighting from the centre of the streets, and had also been made in Lower Thames-street. In testimony of the satisfactory progress of electricity in the City, nothing could be more eloquent than the recent decision of the Commissioners to remove the old gas lamps at an early date from the main thoroughfares, which had been maintained, at an annual cost of about £1,182, ready for lighting in case of failures in electrical illumination. The question of appointing electric light inspectors was now under consideration. Negotiations were in progress with the City of London Electric Lighting Company respecting the use for telephonic purposes of certain of the tubes laid by them, the Commissioners refusing their consent to the tubes being appropriated to any other purpose than for electric lighting without some substantial concession to the ratepayers. With this in view, the Commissioners sought to impose the obligation that the future price of telephones should not exceed £8 per annum. This proposal, however, did not find favour with the City of London Electric Lighting Company, and the matter still remained in the negotiation stage.

The Hobart Electric Tramway.—Some time ago we referred to this tramway, which is worked by an English concern, the Hobart Electrical Tramway Company. The line is single, and is about 10 miles long. The steepest gradient is on the Newtown line, where for about 350 yards there is a 6 per cent. rise. In other places there are some rather severe curves and gradients. The rails are 40lb. Vignoles rails, with guard-rails throughout, the joints being spanned by copper strip riveted to the rails. The trolley wire is supported from poles on either side of the street, galvanised-steel wires being used for suspension. The power-house and carshed are situated near the Hobart river, being built on cement concrete set on piles. The power-house consists of a galvanised-iron shell with wrought-iron girders and columns, with brick and wooden partition walls. There are four Marshall multitubular locomotive boilers, giving steam at 160lb. pressure to three Willans central-valve high-speed compound engines running at 350 revolutions. Two Worthington steam-pumps pump the feed-water through two Marshall feed-water heaters of 100 h.p. each. There are three compound-wound Siemens dynamos, giving 250 amperes each at 500 volts, coupled directly to the engines, on one bed-plate. The shaft of each carries a fly-wheel 4ft. 2in. in diameter. Two Siemens 15-h.p. motors are used for each car, geared to the car axles with single-reduction spur gearing working in oil. The tramway is equipped with a steam and electrical plant, furnished by Messrs. Siemens Bros., of London. The rolling-stock was also furnished by the same company, although the contract was sublet to the Lancaster Wagon Company.

Electrical Trades Section.—A meeting of the Electrical Trades Section of the London Chamber of Commerce was summoned for Monday last, the 22nd inst., at 3.30 p.m., to consider, amongst other matters, the following important questions in their connection with the electrical industry: (1) The advisability of the industry as a whole lending its support to the Antwerp Exhibition, which opens in May next and closes in the following November; (2) a report of the action of the Traction Committee; and (3) the appointment of a Parliamentary Committee. Owing partly, however, to the somewhat short notice that had been given to the members, there was an extremely small attendance, so that, after reading and confirming the minutes of the last general meeting, it was decided—Major Flood Page being in the chair—to adjourn the meeting for a week, when it is hoped and expected there will be a large number of members present to discuss and decide upon the matters brought forward. One reason why the meeting was called for Monday last was that the feeling of the industry might to some extent be gauged with regard to the Antwerp Exhibition, as the English commissioners had arranged to meet yesterday at the Mansion House, and were desirous of being guided as far as possible by the expressed opinions of trades and industries. The Traction Committee, it is understood, have not yet been able to prepare a final report, being still discussing details and definitions with the Board of Trade; but such progress as has been made will be reported to the members at the meeting. We understand that they have been received very favourably by the Board of Trade in their efforts to secure full scope for the free development of electric traction, and it is likely that an actual joint meeting of the committee and Board of Trade officials will take place shortly with a view to discussing doubtful points. The meeting on Monday next, the 29th inst., is to commence at 3 p.m.

Testimonial to Mr. H. Newman Lawrence.—A movement is on foot to present a testimonial to Mr. H. Newman Lawrence, and a circular is now being issued with this object in view by a committee of well-known electrical engineers. We abstract the following from the circular: "The attention of members of the medical and electrical professions is directed to the case of Mr. H. Newman Lawrence, an earnest worker in the field of electro-therapeutics, who finds himself in embarrassed circumstances, brought about, in no small measure, by the disrepute into which electro-medical treatment has gradually fallen in the estimation of the public, through the practices of those with whom Mr. Lawrence has been in no way connected. Throughout he has also been unremitting in his denunciation of quackery in the columns of the *Electrical Review* and other scientific journals, as well as in numerous public lectures. It is a curious instance of the irony of fate that Mr. Lawrence should have been conducive in turning the tide of public opinion to such an extent as to bring about so strong a reaction from blind credulity to utter disbelief in the curative properties of electricity, that the committee understand there is little or no electro-therapeutic work of any kind now being carried on outside the hospitals. The above circumstances, which have come to the knowledge of the members of the committee, seem to them to constitute a case in which they can confidently appeal to their professional brethren—both electrical and medical. They consider that a suitable testimonial would not only be of great service to the recipient, but that it would be both well deserved and worthily bestowed. They have ascertained that Mr. Lawrence has an opportunity of making his way in the United States, and they propose that the funds that may be raised as a result of this appeal should be devoted to furthering this object. Subscriptions will be received by the joint secretaries (Mr. Ed. C. de Segundo, 28, Victoria-street, Westminster, S.W., and Mr. Thomas Adams, 24, Hillfield-road, West Hampstead, N.W.), or they

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may be paid into the 'Lawrence Testimonial' account at Lloyd's Bank, Limited, 54, St. James's-street, London, S.W."

Underground Conduits in the United States.—Of the large number of underground electric wire conduits which have been used or proposed, there are at present in successful use in America, on a large scale, four typical forms: iron pipe, which may be either cast or wrought; cement-lined sheet-iron pipes; tile, terra-cotta or clay pipes; and wood tubes. The most generally used, according to Prof. Jackson in *Cassier's Magazine* for January, are the earthenware conduits, and the most used of them are made of glazed terra-cotta, in sections 3ft. long, with one or more rectangular ducts, each capable of carrying at least three cables. In Milwaukee an ordinary cement sewer pipe has been laid in the same manner as the tile, with cemented joints, and it makes a very fair conduit, which is a little cheaper than the special forms. The pipes are softer than vitrified tile, and therefore more liable to mechanical injury, but the system has not yet been long enough in use to fully decide on its comparative merits. The simplest of all conduits, and one which is used quite generally, is a common wrought-iron gas or steam pipe, either laid bare in the ground or in a bed of concrete. Ducts are usually of 2in. or 3in. pipes, and since a 3in. pipe will carry four ordinary electric light cables, the system is economical of space in the streets. One cable can be pulled out when the others are in the ducts, but the practice of handling cables separately when several are in one duct is not advocated by the most experienced. Joints in the pipe are made with a sleeve screwed on with a vanishing thread, which is cut so that the ends of the pipe comes close together inside the sleeve. The sections of pipe are generally 20ft. long. The great advantage iron pipe has over all other forms of conduit is its flexibility. It may be bent in any direction at any point, to avoid obstacles in the streets, and it should always be used when obstacles are particularly numerous. Some authorities claim that a conduit should never bend, but experience in New York and Chicago proves that cables can be pulled easily around several bends with radii of 3ft. or less. Tubes of wood, treated with various substances to preserve them, have been manufactured by several companies, and quite generally used. At present Philadelphia probably has in use a greater length of wooden conduit than any other city, though there is considerable of it in Chicago and Brooklyn. The commonest form of wood conduit is made up of 4in. by 4in. pieces of wood with a 3in. hole bored through from end to end. These are joined either by a male and female union, or by simply butting the ends together. A cement-lined iron pipe conduit consists of a tough sheet-iron shell, riveted and lined with ⅛in. of pure cement, no sand being used, and the inside being carefully smoothed. The pipes are made in 8ft. lengths and of various diameters. All of these conduit systems are in successful operation on a large scale, but the period of use, the professor concludes, has not yet been long enough to prove positively that they will all endure satisfactorily. The users of each appear to be well satisfied.

Gas Leakage and Electric Light Mains.—Yesterday's issue of the *St. James's Gazette* contained an article on "Electricity as a Street Danger," in connection with the recent explosions of gas in electric light manholes. A representative of that paper has interviewed three electrical engineers on the subject, and the substance of their remarks is given in the article in question. We extract the following: "In every little accident of this kind that I have known," said the engineer in charge at the Westminster Electric Supply Corporation's fine works, "the cause has been the gas leakage and accumulation in either the culverts or the boxes. In the case of the St. Pancras people it would probably be in the culvert; but it all depends what system the cable is laid on. They had three or four cases of this kind at Glasgow recently that caused a little trouble. It is also possible that an explosion of the kind might be due to water getting into the culvert. The current decomposes the water into its constituent gases and the gas is exploded. But I have never heard of but once case where that has happened." Major Flood Page, the deputy-chairman of the Edison and Swan United Company, said: "Did you ever know of earth being turned up in London that didn't smell of gas—even when they were not doing anything to the gas-pipes? Gas has been escaping into the ground for many years, until the earth everywhere around us is permeated with it. Then comes a spark of electricity and sets fire to it." Asked as to why that should happen, he replied: "Well, of course, there may be an excessive current carried along, and some little corrosion of the insulating material may cause a spark. These explosions are not the fault of the electricity; we simply realise now what we have all along known, that these gas-pipes have been permitting gas to saturate the ground. It reminds me that somewhere about 1803 or 1805, when gas was first used in London, the King got into a great fright lest the streets should be blown up; and a number of the leading scientific men of that day solemnly assured him that there was no foundation for the fear that the horses going along in them would be sent flying into the air. We have found they were quite right—that people and horses have not been sent flying up into the air—but all the same, the gas-pipes have leaked, the ground has become saturated with gas, and now the presence of the electric cables has introduced an element of danger. But it is not at all a serious matter. This kind of thing will happen very occasionally, and so far we have no misfortune to lament. I don't think there need be the slightest alarm." The Major further stated that he did not anticipate that there will be any serious number of accidents. Continuing, he remarked on the question of low tension *versus* high tension: "The low tension means that they work at about 100 volts pressure, and the high tension that they work at about 5,000 volts, but transform it down before it gets into the consumers' houses. Inside the houses the one kind is as safe as the other. Outside the houses—well, no accident can happen from a man laying hold of a low-tension system, but a man might be killed by laying hold of a high-tension. When the Americans tried to kill criminals by electricity they were at first laughed at because it took so long to do it. They applied electricity to the head and the hair, which is the worst conductor we have in our body; whereas a man who grasps a wire with his hands instantly forms a circuit and brings the whole current through his body, and a high-tension current would kill him. But, high or low, there is not the slightest danger of any gas-main exploding or being in any way affected by the currents passing along the electric mains. If you come to think," pursued the Major in a burst of eloquence, "of the enormous use of electricity now, and the millions of incandescent lamps and thousands of arc lamps that are being used all over Europe, and with an infinitesimal percentage of accidents—not anything like the number from gas; and when you remember that the use of gas, lamps, and candles causes something over 500 fires in the London district every year, while the number caused by electricity doesn't reach more than three or four, you will see that there can be no question—it is absolutely beyond dispute—that electric lighting, carried out as it is here with care and proper caution, is by far the safest artificial illuminant the world has ever known."

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ELECTRIC LIGHT AND POWER.

BY ARTHUR F. GUY, ASSOC. MEM. INST. ELECTRICAL ENGINEERS.

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(Continued from page 9.)

INSULATION.

The object of insulating matter put on copper conductors is to confine the current as much as possible to the copper, and to allow as little as possible to flow through other paths and so leak away. The leakage of water in a pipe is somewhat analogous to the leakage of the electric current flowing along a conductor: the longer the pipe and the more joints there are in it, the greater will be the chance of leakage; and it is similar with electricity. The two typical substances for conducting and insulating purposes as used in practice are copper and indiarubber. The conductor is made of copper, because it is desirable to have the resistance to the current as low as possible; the insulation is made of indiarubber, because it is desirable to obstruct the current as much as possible. The copper conductor is made of such a sectional area that a certain current can flow without unduly heating the metal; and since the specific resistance of indiarubber is enormously higher than that of copper, it follows that only a most minute current can leak through the insulation. The conditions under which electricity is supplied reduce considerably the great difference between the two, and instead of the ratio of the specific resistances of indiarubber and copper being billions to one, it is brought down to thousands to one, which is a ratio we are more capable of conceiving.

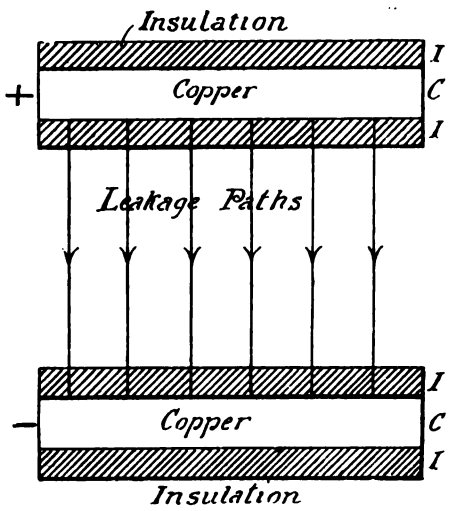

FIG. 40.

We will consider the case of a couple of conductors, say, 200 yards long, and take the ratio of the specific resistances of insulation and copper as $6 \times 10^{16} : 1$. Let the depth of the insulation be, say, ·5cm., and the diameter of the copper 1cm., as shown in Fig. 40; then considering the insulating matter first, the length of its path is extremely short, while the cross-sectional area is enormous. The reason of this is because the current does not tend to flow along the cylindrical tube of insulation, but tries to flow *through* the insulation covering *in the direction of its depth*, and thus through the air space or whatever intervenes between the two conductors, then through the depth of the insulation of the second conductor, and so complete its circuit. This leakage does not happen at one point or many, but at every point along the conductors, and at every point around the circumference. This being so, the sectional area of the insulation is measured by the cylindrical surface exposed by the whole of the conductors, and this surface is obtained by multiplying the length of the conductor by the mean circumference.

The total length of the insulating path is extremely short, being evidently the depth of the insulating matter that covers the copper conductors, and as there are two conductors so this total length is measured by twice the depth of the insulation. The intervening space between the copper conductors cannot always be calculated as part of the insulating path, because the insulation on each conductor is in contact with earth at some points. And even when the conductors are suspended in air, or embedded in bitumen-filled pipes, there is bound to be some supporting points where contact of the insulation with earth occurs.

The following gives a general law showing the ratio between the two:

Let l signify length of cable;
„ D „ outer diameter of insulation;
„ d „ inner „ „ „

Then $\frac{1}{2}(D-d)$ signifies thickness of insulation, and d signifies diameter of conductor.

The sectional area of the conductor $= \pi d^2 \div 4$;

„ „ „ „ insulation $= \left(\frac{D+d}{2}\right)\pi l$;

the length of the conductor $= 2l$;

„ „ „ insulation $= (D-d)$.

It is assumed, to simplify matters, that the two cables are buried, say, a foot apart in the ground, which we will further assume is slightly moist, so that the outside surfaces of the insulating matter on each cable is being to earth in a most evident manner. The resistance of the path of the leakage current is measured simply by the thickness of the insulation on each cable, because the resistance offered by the "earth" is of a negligible quantity; the thickness of the insulation being $\frac{1}{2}(D+d)$, and there being two thicknesses to penetrate—one on the positive cable and one on the negative—the total path = twice the thickness, or $(D-d)$. The mean diameter of the tubular insulating covering is evidently $\frac{1}{2}(D+d)$; hence the mean circumference is obtained by $\frac{1}{2}(D+d)\pi$, and multiplying this by the length, l, gives the mean sectional area $= \frac{1}{2}(D+d)\pi l$. Inserting the respective values, we thus have:

$$\text{For conductor} \quad R_c = \frac{8l}{\pi d^2} + \rho.$$

$$\text{For insulation} \quad R_i = \frac{D-d}{l\pi\left(\frac{D+d}{2}\right)} + \rho_1,$$

where ρ and ρ_1 signify the specific resistances of the copper and insulation covering respectively.

It is impossible to say what the specific resistance of insulating covering might be. The maximum would be if the covering were made entirely, say, of indiarubber, but of course it never is—the number of layers of indiarubber put on varying with the quality and make of the cable. We will assume, therefore, that specific resistance of the covering, is, say, 6×10^{16}; that of indiarubber being about 6×10^{20}, copper being taken as unity.

Hence, the ratio of the specific resistances of the insulation and copper is $6 \times 10^{16} : 1$. Inserting the value of 6×10^{16}, we have the ratio between insulation and conductor:

$$6 \times 10^{16}\left\{\frac{D-d}{l\pi\left(\frac{D+d}{2}\right)}\right\} : \frac{8l}{\pi d^2};$$

or,
$$6 \times 10^{16}\left(\frac{D-d}{D+d}\right) : \frac{4l^2}{d^2};$$

or,
$$1{\cdot}5 \times 10^{16}\left\{\frac{d^2}{l^2}\,\frac{(D-d)}{(D+d)}\right\} : 1.$$

Fig. 40 gives a sectional view of a pair of insulated conductors showing the leakage paths across from copper of one conductor to the copper of the other. From this it can readily be understood how it is that when mains are laid along casing which becomes moistened or damp, the leakage is increased. Although the difference between the specific resistance of the insulation and that of the conductor is so enormous, yet it is reduced quickly. The length of the conducting path was assumed to be 400 yards, and the length of the insulating path is taken as twice the depth, or $2 \times {\cdot}5 = 1$cm., so that the latter path is only about $\frac{1}{400 \times 36 \times 2{\cdot}54} = \frac{1}{36{,}576}$ of the length of the former. The ratio at the start was taken as $6 \times 10^{16} : 1$, and

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TABULATION 31.—Specific Insulation (σ) of Electric Light Cables Manufactured by Various Firms.

Manufacturer.	Conductor.			Dielectric.				Insulation per mile at 60 deg. F., megohms.	Specific insulation (σ).	Remarks on insulation.
	No. of wires and approximate gauge.	Diameter.		Thickness (t).		Diameter (D).				
		inch.	mm.	inch.	mm.	inch.	mm.			
Siemens Bros. ...	7/22	·084	2·14	·076	1·93	·236	5·99	16,180	15·84	Siemens high-insulating indiarubber.
,, ...	,,	,,	,,	·078	1·98	·240	6·10	18,270	17·60	
,, ...	19/15½	·340	8·64	·079	2·03	·501	12·72	1,022	2·67	Ordinary pure and vulcanised rubber.
,, ...	61/15½	·612	15·54	·168	4·27	·949	24·10	824	1·90	
,, ...	51/12	·850	21·59	·190	4·82	1·230	31·24	4,082	11·17	Lead cased; high-insulating fibrous material.
,, ...	37/13	·651	16·53	·096	2·44	·844	21·43	2,567	10·00	
,, ...	19/14	·410	10·41	·079	2·01	·568	14·42	3,794	11·77	
,, ...	7/13	·286	7·26	·079	,,	·444	11·28	6,389	14·69	
,, ...	60/6½	1·656	42·06	·118	2·87	1·882	47·80	624	4·93	Lead cased; impregnated fibrous material.
,, ...	,,	,,	,,	,,	,,	,,	,,	830	6·56	
,, ...	60/10	1·170	29·72	·114	2·89	1·398	35·51	851	4·83	
,, ...	,,	,,	,,	,,	,,	,,	,,	1,014	5·76	
Silvertown.....	19/15	·360	9·14	·144	3·66	·648	16·46	6,768	11·64	Pure indiarubber, then vulcanised indiarubber.
,, ...	,,	,,	,,	,,	,,	,,	,,	6,664	11·46	
,, ...	,,	,,	,,	,,	,,	,,	,,	6,549	11·26	
Callender	7/16	·192	4·88	·154	3·91	·500	12·70	380	·40	Vulcanised bitumen.
,, ...	19/18	·240	6·10	·155	3·94	·550	13·97	400	·49	
Glover	19/13	·460	11·68	·115	2·92	·690	17·52	600	1·50	Pure and vulcanised rubber.
,, ...	,,	,,	,,	,,	,,	,,	,,	515	1·28	
,, ...	,,	,,	,,	,,	,,	,,	,,	560	1·40	
,, ...	7/16	·192	4·88	·055	1·40	·302	7·67	855	1·91	
,, ...	,,	,,	,,	,,	,,	,,	,,	813	1·81	
,, ...	,,	,,	,,	,,	,,	,,	,,	833	1·86	
Fowler-Waring ..	1/18	·048	1·22	·036	·91	·120	3·05	6,522	7·20	Waring compound.
,, ...	1/16	·064	1·62	·043	1·09	·150	3·81	6,619	7·85	
,, ...	7/16	·192	4·88	·078	2·03	·352	8·94	4,835	8·07	
,, ...	19/18	·240	6·10	,,	,,	·400	10·16	3,280	6·48	
,, ...	19/16	·320	8·13	·095	2·41	·510	12·95	3,312	7·18	
,, ...	19/15	·360	9·14	·100	2·54	·560	14·22	3,145	7·19	
Henley	1/10	·128	3·25	·046	1·17	·220	5·59	564	1·05	Pure and compound indiarubber.
,, ...	7/16	·192	4·88	·054	1·37	·300	7·62	406	·92	
,, ...	19/18	·240	6·09	·060	1·52	·360	9·14	329	·82	
,, ...	1/14	·080	2·03	·040	1·02	·160	4·06	4,440	6·48	Ozokerited indiarubber.
,, ...	3/30	·078	1·98	·039	·99	·157	3·99	5,210	7·57	
,, ...	7/15	·216	5·49	·057	1·45	·330	8·38	2,210	5·27	
,, ...	19/14	·400	10·16	·080	2·03	·560	14·22	2,000	6·01	
,, ...	61/15	·648	16·47	·111	2·82	·870	22·09	2,200	7·55	
,, ...	61/12	·936	23·77	·217	5·51	1·370	34·79	7,146	19·98	Special cable—Class AA.

this now becomes reduced at once to more than 36,000 times, because the conducting path is about 36,000 times as great as the insulating path. Again, we must consider the ratio of the sectional areas of the two paths. The sectional area of the conducting path is $\frac{3{\cdot}1416 \times {\cdot}5^2}{4} = {\cdot}2$ square centimetre. The sectional area of the insulating path is the mean circumference of insulation × length of conductor = $1{\cdot}5 \times 3{\cdot}1416 \times 200 \times 36 \times 2{\cdot}54 = 86{,}180$ square centimetres. Thus the sectional area of the second is 430,000 times as great as that of the first, and consequently the resistance of the insulating path will be reduced 430,000 times, and the ratio is now further reduced, so that finally the insulating path may be taken as having a resistance about $1{\cdot}5 \times 10^9$ times as great as that of the conducting path, and hence a most minute part of the total current leaks away through the insulation, and is wasted. All these figures are very approximate to the case considered, and are given simply to give an idea of the relation that may exist between the insulating and the conducting paths. The amount of the leakage current is about the best test we can have respecting the state of the insulation on an electric light circuit.

It is of the utmost importance that every part of the circuit of an installation should be well insulated, otherwise there will be continual trouble—the current will leak, fuses get blown, and the short-circuits may overheat the wires and cause a fire to break out. The state of the atmosphere has a great deal to do with the condition of the insulation of the circuit. If the weather be fine and dry, very little leakage will be discovered on testing; but test the same circuit on a wet day, when the atmosphere is charged with moisture, and very different results are sometimes obtained. The damp air produces moisture on the surfaces, and so enables the current to creep or leak. This "surface leakage" is not confined to such material as wood, but also acts on such insulators as glass and porcelain, materials which in dry weather form excellent insulators. It must be remembered that England is a rainy country, and has more often a moist than a dry atmosphere—in fact, we rarely get a dry atmosphere such as is known in warmer climes, so insulation which will do for other countries will not do for us. In addition to the leakage itself, moisture tends to set up electro-chemical action, and the insulation and the copper thus get acted on chemically and destroyed. All circuits should be systematically and frequently tested, so that the slightest sign of any incipient fault becoming developed can be detected as soon as possible and the fault removed before it can do any harm. The insulation resistance of electric light cables is quoted as so many megohms per mile. This expression is technically wrong, because insulation resistance varies inversely as the length of the cable—that is, if one mile of cable has a resistance of 1,000 megohms, then half a mile will have an insulation resistance of 2,000 megohms, and two miles 500 megohms, etc.; hence the insulation resistance should be expressed as one factor of a product. Thus 1,000 megohm-miles, meaning one mile, will be 1,000 megohms, or 1,000 miles will be $\frac{1}{1000}$ of a megohm = 1,000 ohms.

High-insulation cables are made to give 1,000 megohm-miles, and are insulated with vulcanisod indiarubber, which material seems to find most favour for insulating purposes. A cable of this class would be suitable for high-pressure currents. For low-pressure currents the insulation resistance need not be so high, 300 megohm-miles being reckoned sufficient.

Insulated cables have now been brought to a high standard of perfection, particularly since high-pressure currents have been in general use, and where the conductor is required for damp places the exigencies of the case have been successfully coped with. Each manufacturer has his own ideas respecting the best method of building up the insulation covering, and we think we cannot do better than to append the valuable tabulation drawn up by Mr. W. H. Preece, as given in his paper, entitled "Specification of Insulated Conductors for Electric Lighting and other Purposes," read before the Institution of Electrical Engineers on December 10, 1891.

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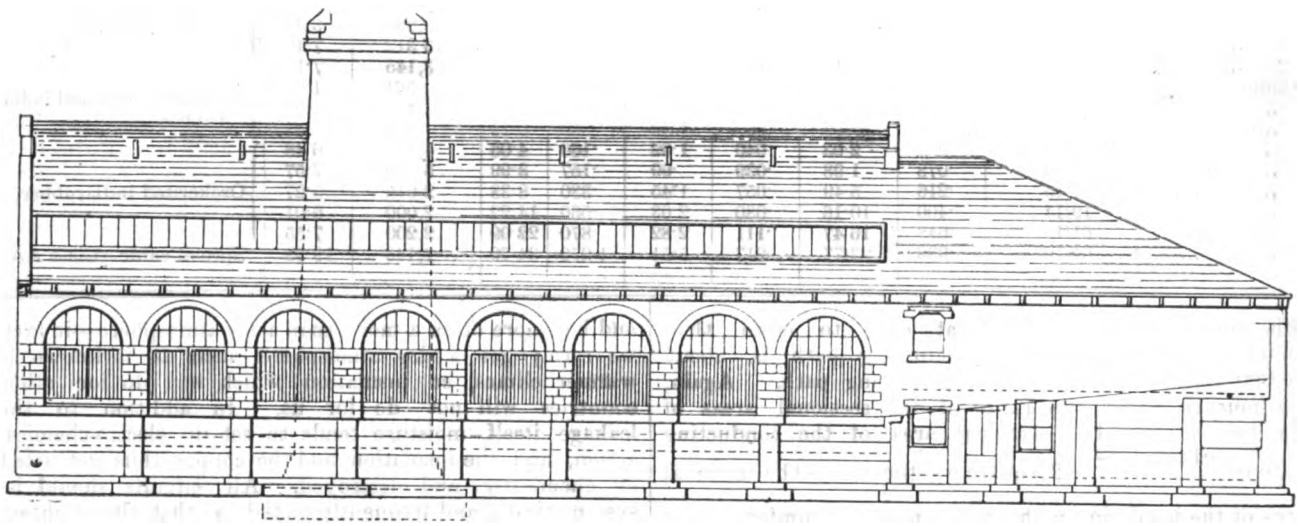
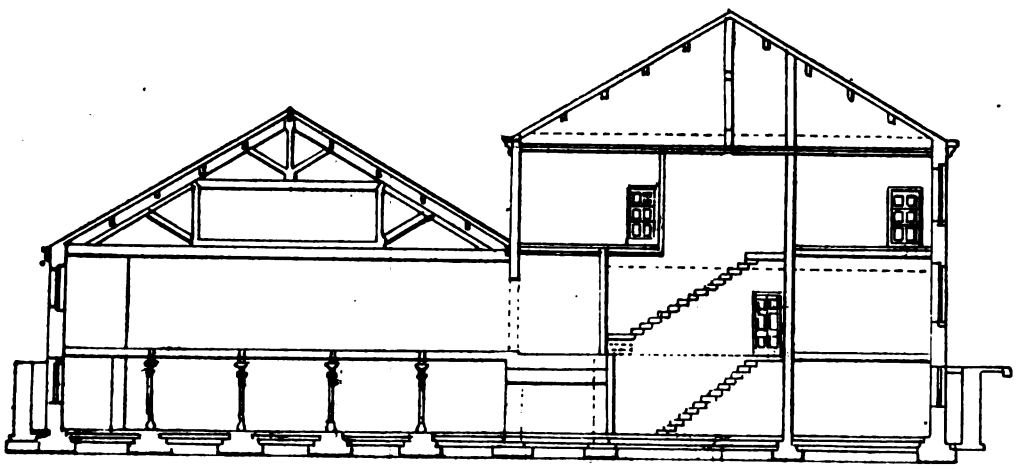
HUDDERSFIELD ELECTRICITY SUPPLY.

The following description of the Huddersfield municipal electricity supply station has a peculiar interest for engineers and members of a local authority, for it is an instance of a thoroughly successful undertaking conceived and carried into execution by the will of a far-seeing Corporation working through an energetic committee. Huddersfield has played the *rôle* of pioneer in many municipal undertakings, and when face to face with the electric lighting question, acted upon its usual courage of conviction at a time when many doubted the wisdom of municipalising electricity supply, and the utmost ignorance and prejudice prevailed against the use of high-tension generation of the electric current. Time has rapidly, since the Huddersfield Corporation threw their weight into the scale of both of the above causes, justified their foresight. The initiation of the undertaking was delegated to the Gas Committee, who visited a number of towns with a view to inspecting the various available systems. After very careful consideration of the

SOUTH ELEVATION



WEST ELEVATION



SECTION

Huddersfield Electricity Supply Station.

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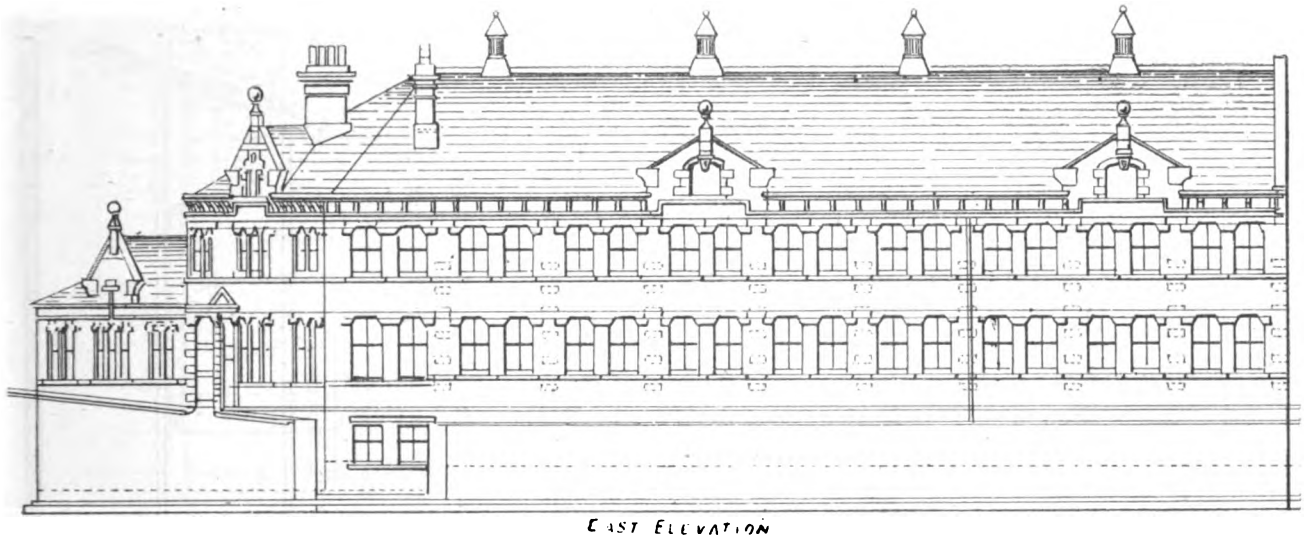
respective advantages offered, they decided that the balance was in favour of distribution by low pressure with generation at high pressure by alternate currents. This at once enabled them to remove the works away from the centre of the town, and at the same time to extend their supply area until the whole of the somewhat scattered outlying districts are included. Having obtained tenders from those firms who were in a position to carry out the whole undertaking, they accepted that of the Brush Electrical Engineering Company.

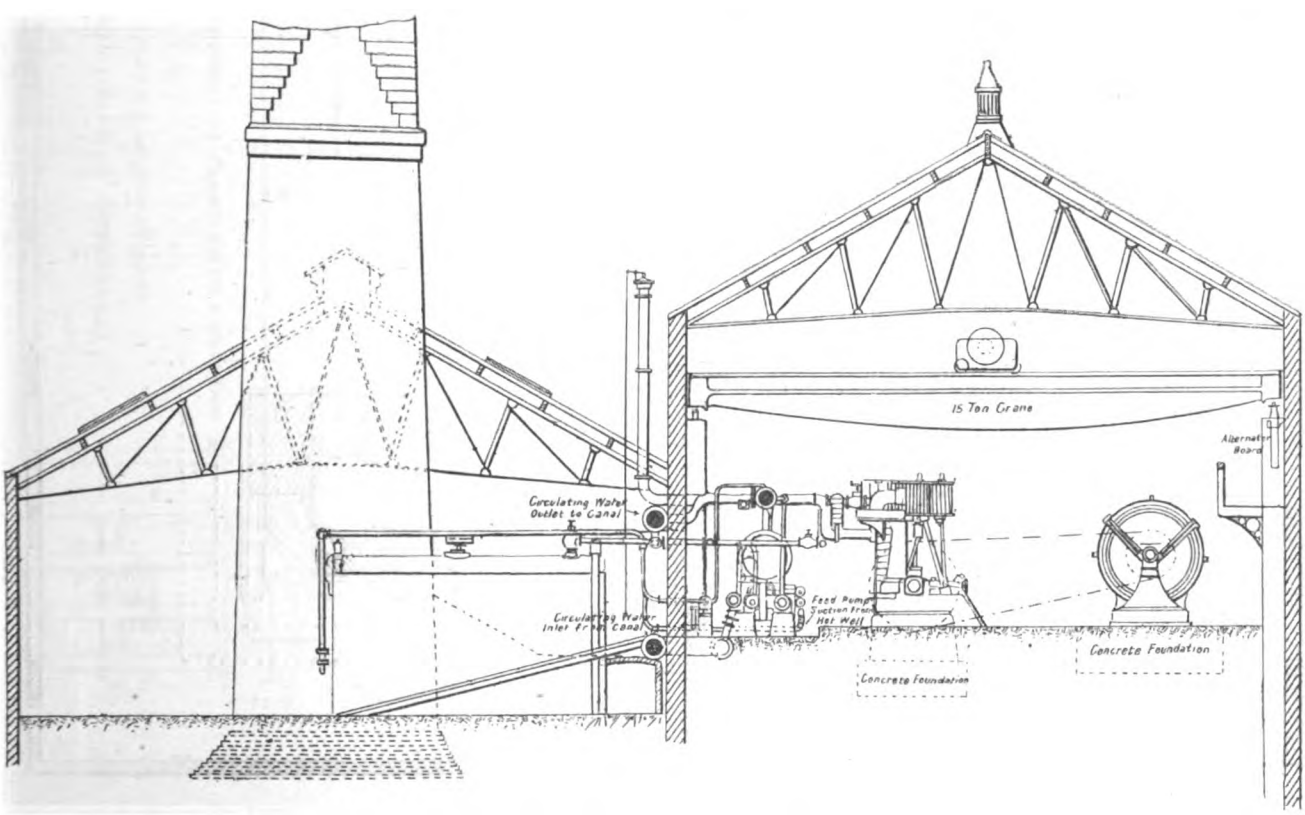
Application was duly made to the Local Government Board, whose sanction was obtained in May, 1892, when the buildings were promptly commenced. In July, however, an untimely strike in the masons' trade so delayed the work that all hope of completing in time for last winter was abandoned. The inauguration took place on July 29 last, since which date the Corporation have provided a continuous supply throughout the principal streets.

The generating station, of which we give several views, together with detailed plan and elevation, is situate on land adjoining the canal and the gasworks (which are also the property of the Corporation). The buildings, which are most substantial, have a frontage in St. Andrew's-road of 117ft., the engine-room being 105ft. long by 50ft. wide, the boiler-house being the same length and 54ft. wide. The chimney, which is 6ft. internal diameter and 200ft. high, is unusually handsome; we give a sectional view of it. It was designed by Mr. B. Stocks, the chairman of the Gas Committee, whose unsparing services have very largely contributed towards the successful introduction of the electric light into Huddersfield. The buildings have been specially designed with a view to facilitate the carrying out of future extensions, while at present plant for 40,000 lamps can be conveniently accommodated.



Huddersfield Electricity Supply Station.

Boilers.—Steam is supplied to the first instalment of plant from four Babcock-Wilcox boilers, each capable of supplying about 5,000lb. of steam per hour at 150lb. pressure. Each boiler has a heating surface of 1,411 square feet, and a grate area of 26½ square feet, and each has 63 tubes 4in. diameter and 18ft. long, with a steam drum 36in. diameter and 23ft. 7in. long. The brick setting of the boilers has been specially designed by the Brush Electrical Engineering Company's superintending engineer (Mr. Geipel) with a view to minimising loss by radiation from the brickwork,



Section—Boiler and Engine Room—Huddersfield.

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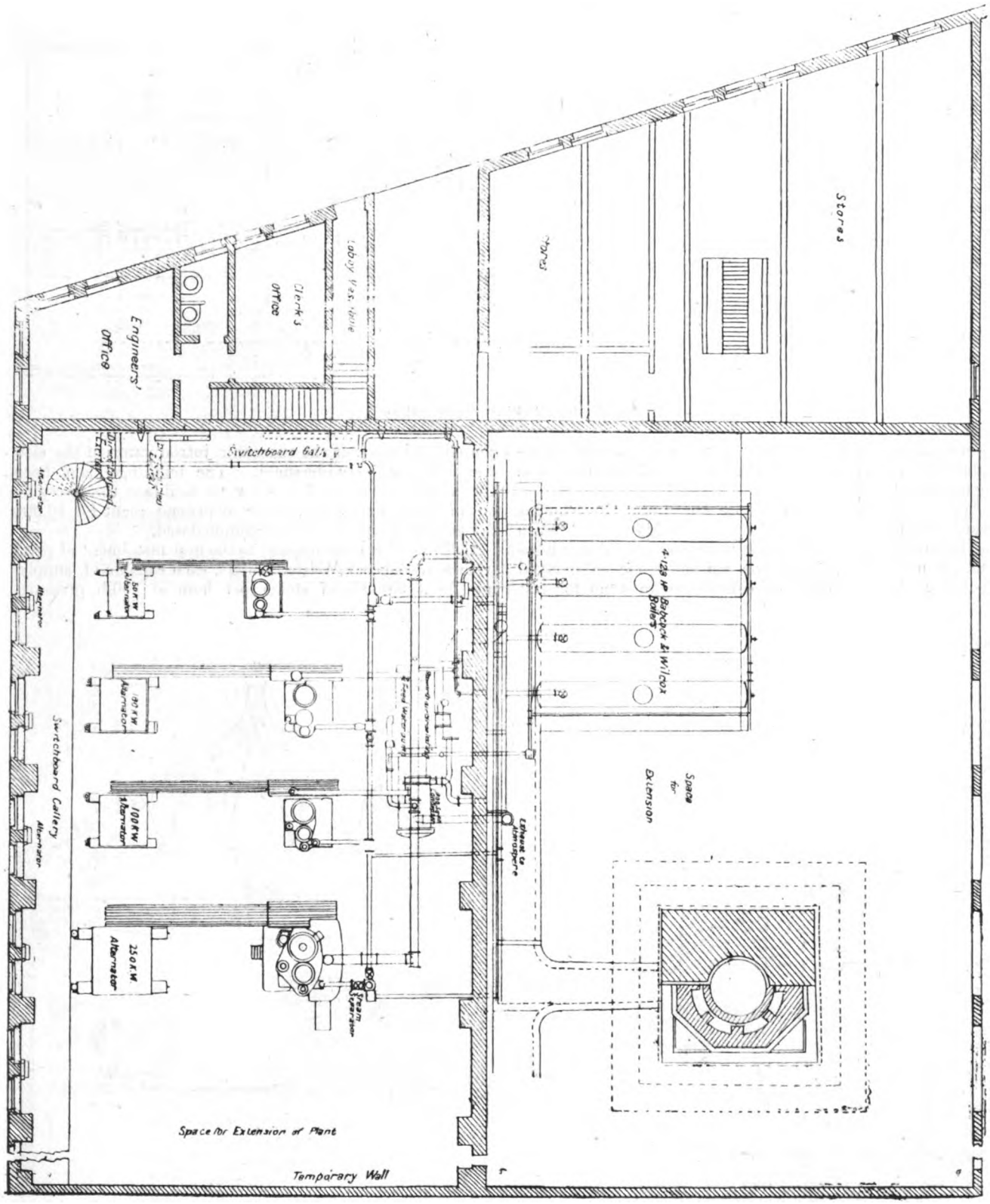
and although no careful tests have yet been made, some economy may be expected, as it has been ascertained that the heat of the outside walls is less than with the usual settings. An illustration of this setting is given in which it will be seen that an air-space divides the inside from the outside of the setting, thus reducing the transmission of heat to outside.

pipe to operate the exciter engines. The whole of the valves are of the parallel slide type, so that when open the steam has a straight passage through ; while in the larger valves it is arranged that the first turn of the handwheel opens a small by-pass valve, which at once serves to prevent too sudden an influx of steam, and relieves the pressure on the main valve, so that the latter may be opened



Plan of Station—Huddersfield.

Crane.—The engine and dynamo room is traversed by a 15-ton crane, operated either by hand or by a 9-h.p. Brush-Victoria motor, current being obtained from one of the exciters, the various movements being controlled by clutch gear.

Steam-pipe.—The main pipe is of wrought iron 6in. in diameter, and forms a ring with valves so arranged that any section may be isolated. The branches to the main engines are 4in. and 3in. Reducing-valves are inserted in each steam-

with ease. The exhaust piping, which is of cast iron, ranging from 10in. diameter downwards, opens into the condenser or direct to atmosphere, as may be desired. There is an automatic relief valve on the pipe which opens the exhaust to atmosphere in the event of stoppage of the condensing plant, while a large straight-through valve shuts off the condenser when required.

Condensing Plant.—This is so arranged that it may be readily extended along with the engines, for which

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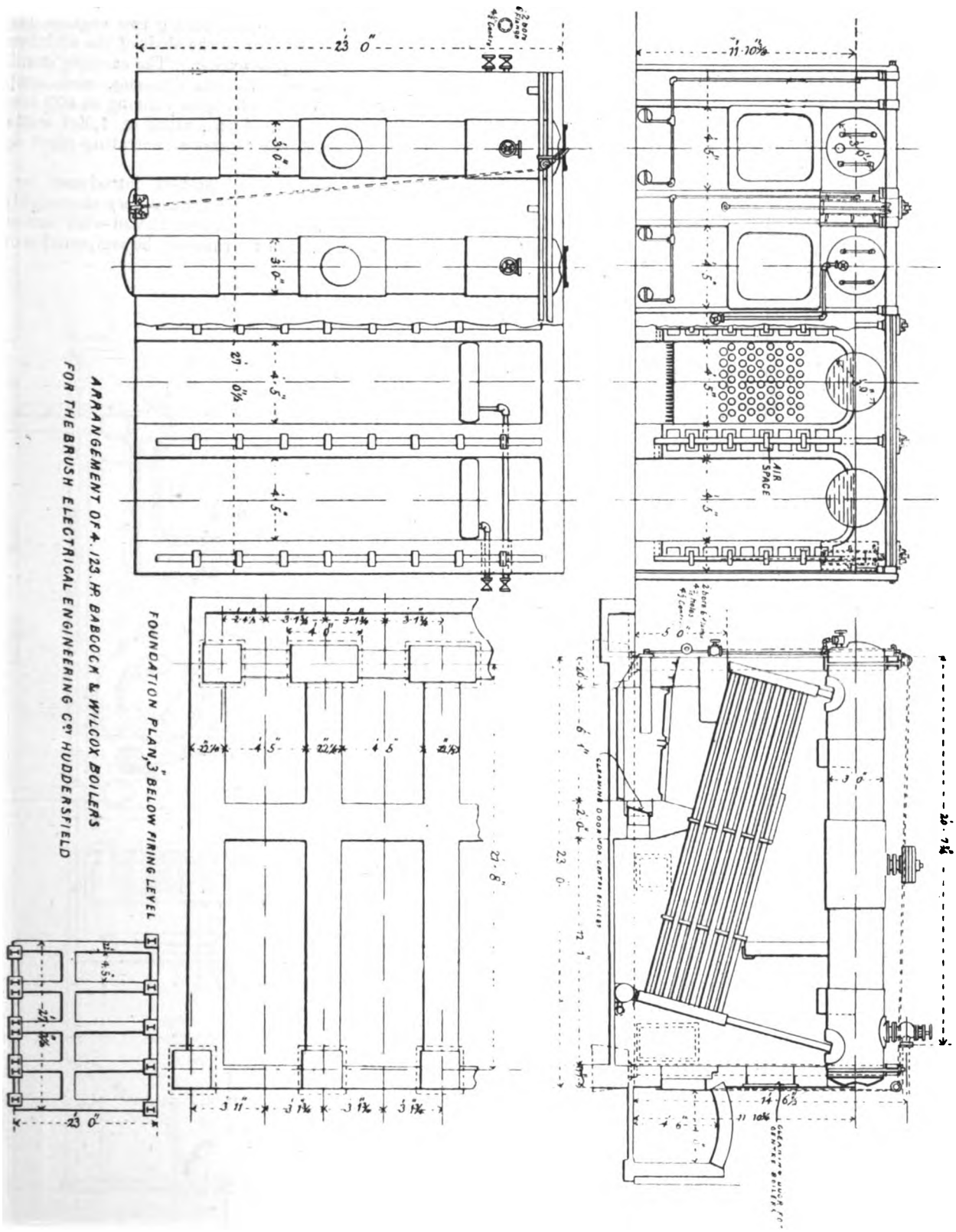
reason a 16in. pipe has been fixed for leading the cooling water from and to the canal. This pipe is capable of supplying water for about 10 times the cooling surface of the present plant, and is arranged so that it may be tapped as each additional condenser is fixed. At present there is only one surface condenser of 900 square feet cooling surface, into the top of which leads a branch from the


ARRANGEMENT OF 4-123 HP BABCOCK & WILCOX BOILERS
FOR THE BRUSH ELECTRICAL ENGINEERING Co. HUDDERSFIELD
FOUNDATION PLAN 3" BELOW FIRING LEVEL
AIR SPACE
23 0"
11 10¾
Huddersfield Electricity Supply Station

main exhaust with a valve for closing the inlet. The Raworth air and circulating pumps are horizontal, and are fixed on one bed-plate, and are driven by a pair of compound cylinders. This combination has been specially designed for central-station work, with a view to economise the consumption of steam. The whole of the pumps are worked by one pair of compound cylinders, while a heavy flywheel is provided to enable the steam to be cut off and used expansively. The diameter of the air-pump is 13in., the circulating-pump is 11in., the high-pressure cylinder 5in., and the low-pressure cylinder 8½in., and the stroke of each is 10in. A by-pass valve is fixed on the circulating-pump in order to control the cooling water to suit the quantity of steam to be condensed, and to regulate the temperature of the hot-well. A general idea of the pump may be obtained by reference to the plate.

Feeding Arrangements.—The principal feed pumps are driven by the same engine as the air and circulating pumps from a rocking shaft. The pump rods are attached to blocks which slide in slotted levers, by means of which the stroke may be varied as required. The feed-water is drawn from the hot-well under the air-pump, a replenishing cock being fitted to both the town supply and to the circulating or canal-water pipe, so that the feed may be made up from either source. In addition to this there is a Worthington

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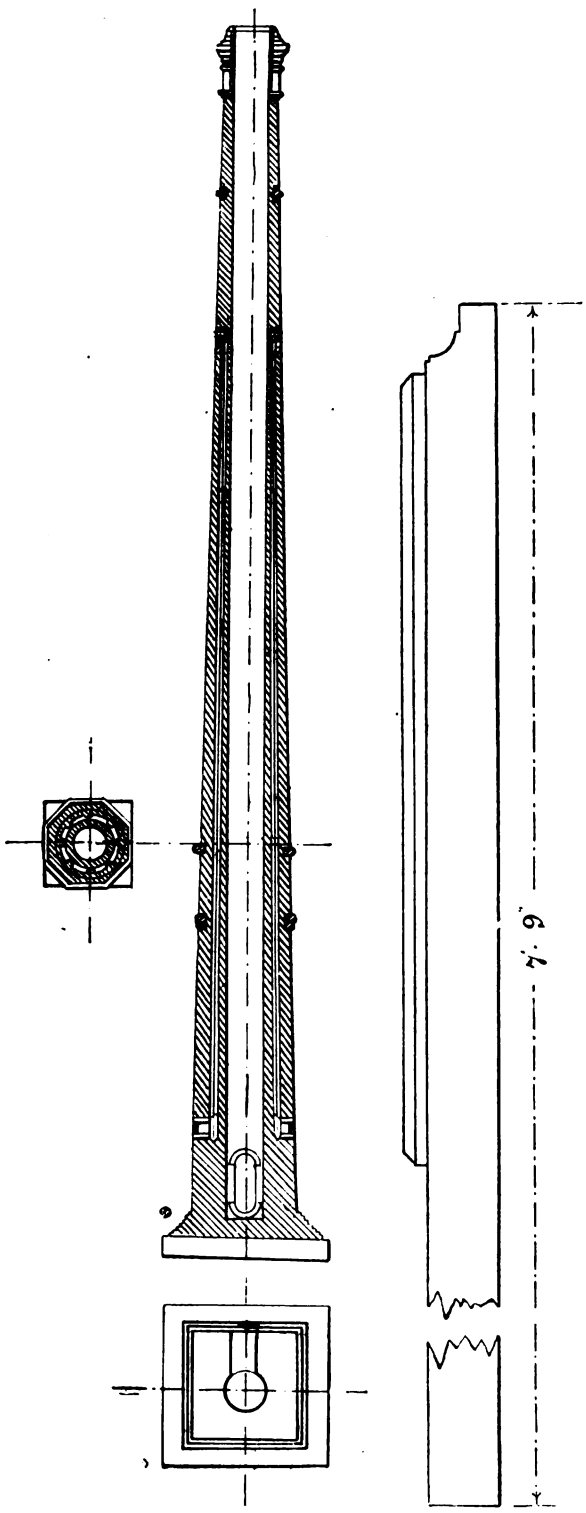
pump supplied as a stand-by—this pumps direct into the boilers from either town supply or canal pipe. The feed-pipe is also arranged on the ring-main principle, with suitable valves for isolating any section. The branch feed pipes are entirely of copper.

The Main Engines.—In the first case these were three in number, two of which have cylinders 15in. and 25in. by 16in. stroke and run at 167 revolutions per minute. The high-pressure cylinders are fitted with piston valves, and the low-pressure with slide valves. They are controlled by a flywheel governor acting on the high-pressure valves. The governor is fitted with Raworth's patent adjustment for altering the speed while running, and for dividing the load as required between the various machines running in parallel. The low-pressure slide valves are provided with Hackworth's gear for varying the cut off in the low-pressure cylinder whilst running, so that the engines may be operated with the best results for any load. We illustrate one of these engines. The small engine is similar to the larger engines, except that an Acme throttle-valve governor is used. The cylinders are 11in. and 18½in. diameter by 12in. stroke, and the speed 200 revolutions per minute.

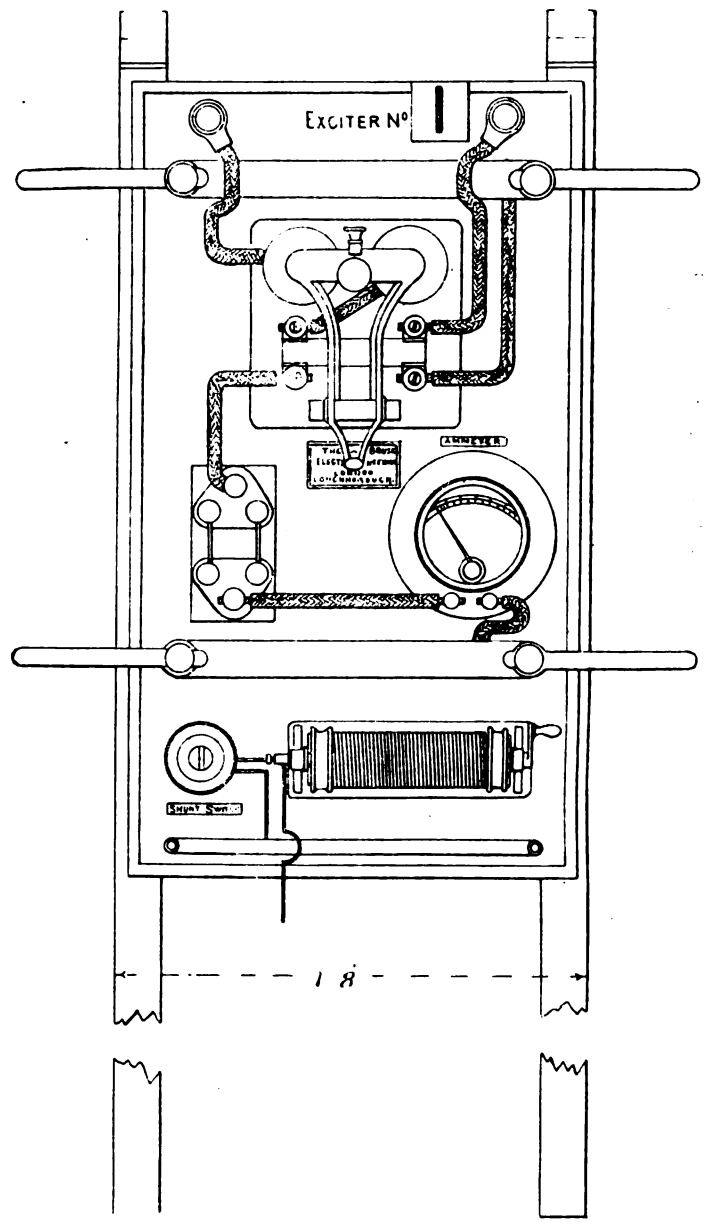
Alternators.—The alternators, which are of the well-known Mordey-Victoria type, are driven from the above engines by means of separate cotton ropes. Two of these (see illustration) run at 430 revolutions, and have a capacity of 100 kilowatts each, whilst the third runs at 600, and works up to 50 kilowatts, the pressure being 2,000 volts.

Exciting Plant.—To obviate running two engines during the light load, there is fixed on the shaft of the 50-kilowatt alternator a small two-pole exciter. The exciting omnibus bars are fed from two Victoria dynamos, each coupled direct to a 6in. by 5in. Brush engine running at 400 revolutions, and each capable of an output of 4,500 watts at 65 volts; this is sufficient to excite generating plant up to about 500 kilowatts capacity.

Switchboards.—The "Unit" system, introduced by the Brush Company, has been carried out very thoroughly in this station; each exciter has a switchboard with ammeter and zero cut-out arranged for running the compound-wound exciters in parallel on to the exciter omnibus bars. Platinoid resistances wound on bars of slate with a sliding contact are used in the shunt circuit for regulating the pressure of the exciters, and through them of the whole station. The station voltmeter is fixed immediately over these resistances. The field of each alternator is connected to the exciting mains by a special switch, which puts in a water resistance when the circuit is being opened, and so obviates the effect of suddenly opening the field circuit. Opposite each alternator there is a board containing double-pole high-tension



Plan of Chimney—Huddersfield.



Exciter Board—Huddersfield

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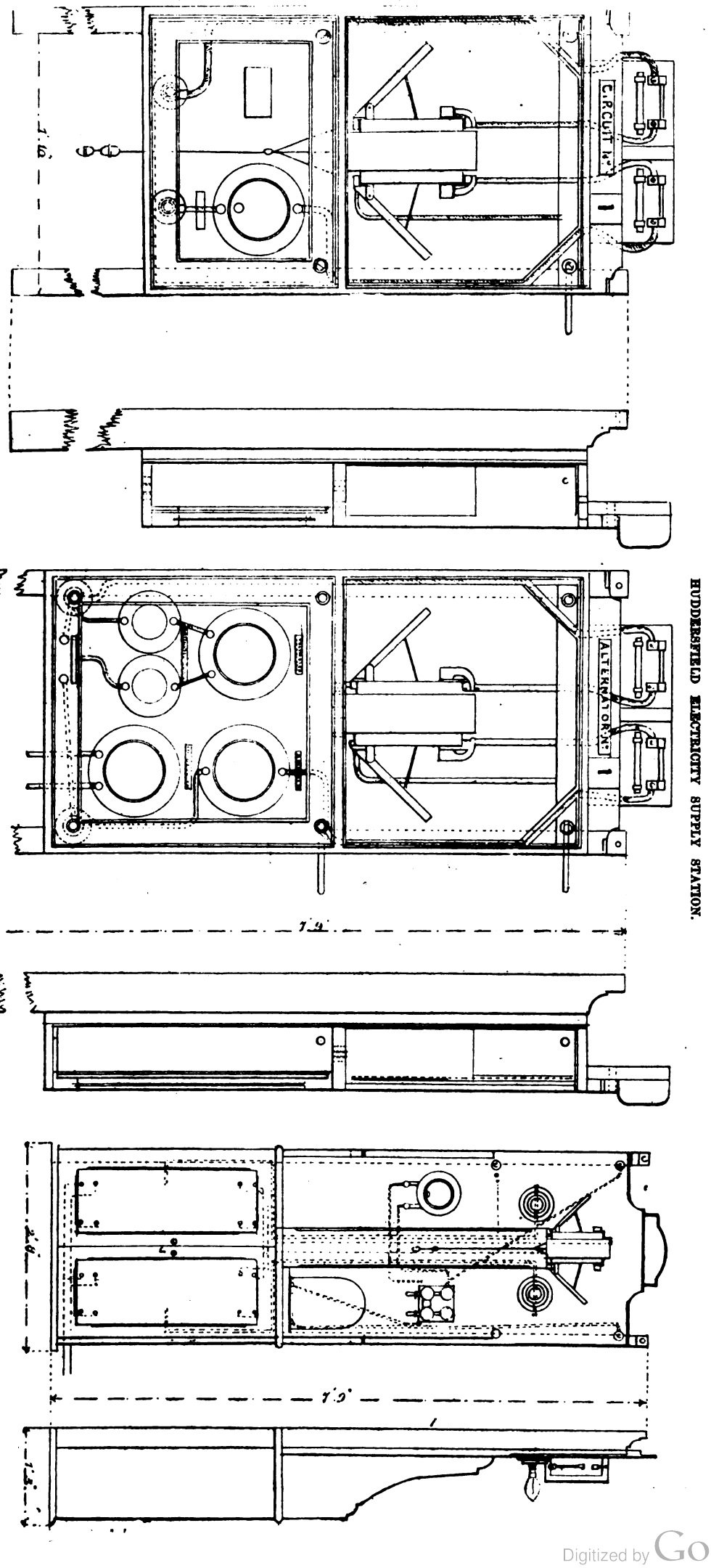

Alternator, Circuit, and Synchroniser Board.

HUDDERSFIELD ELECTRICITY SUPPLY STATION.

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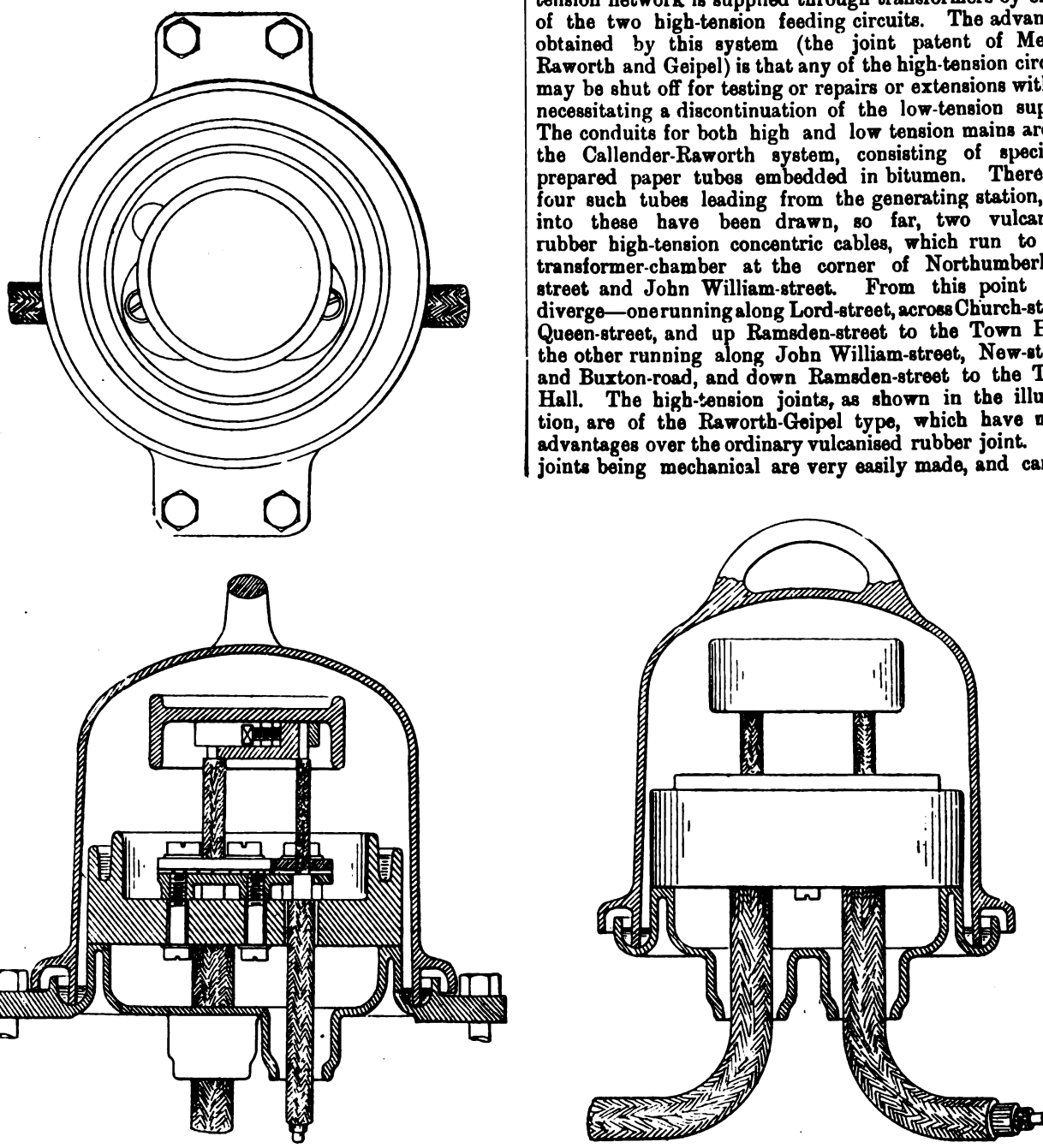
fuses and switches for connecting the machine to the station omnibus bars, and also an alternate-current ammeter, a voltmeter on one coil of the armature, and an ammeter on the field circuit. There is also a small double-pole plug switch for connecting the alternator to the synchroniser. The synchroniser board contains two synchronisers and lamps, together with double-pole switches for connecting the synchroniser to the station omnibus bars. It also carries the main station ammeter and the main station recording meter, which is of the Shallenberger type, while provision is made on the board for a recording watt-meter. After passing through this board from the alternators the omnibus mains proceed to the circuit boards, of which at present there are two; each carries an ammeter and double-pole high tension switch and fuse. One example of each of the above boards is illustrated. It will be seen that this system allows of the addition of any number of exciters, alternators, circuits, and their corresponding boards, without in any way interfering with the existing arrangement. The switchboards are all operated from a gallery running along two sides of the engine-room, and are so placed as to correspond with the machines to which they belong. Access to the gallery is obtained directly from the offices of the electricians, which are on the first floor, or by circular stairs from the engine-room.

Testing Wires.—From the testing-room are run wires to various parts in the machine-room, where terminals are fitted for rapid connection with any of the machines and circuits. A very complete set of testing instruments has been provided.

The whole of the engine-room plant has been manufactured by the Brush Company at their Loughborough works.

Distribution.—The distribution is effected by low-tension distributing mains, 100 volts pressure, running from the transformer sub-stations, which are situated at convenient points in the town, while it is so arranged that the low-tension network is supplied through transformers by either of the two high-tension feeding circuits. The advantage obtained by this system (the joint patent of Messrs. Raworth and Geipel) is that any of the high-tension circuits may be shut off for testing or repairs or extensions without necessitating a discontinuation of the low-tension supply. The conduits for both high and low tension mains are on the Callender-Raworth system, consisting of specially-prepared paper tubes embedded in bitumen. There are four such tubes leading from the generating station, and into these have been drawn, so far, two vulcanised rubber high-tension concentric cables, which run to the transformer-chamber at the corner of Northumberland-street and John William-street. From this point they diverge—one running along Lord-street, across Church-street, Queen-street, and up Ramsden-street to the Town Hall; the other running along John William-street, New-street, and Buxton-road, and down Ramsden-street to the Town Hall. The high-tension joints, as shown in the illustration, are of the Raworth-Geipel type, which have many advantages over the ordinary vulcanised rubber joint. The joints being mechanical are very easily made, and can be inspected by merely lifting off the cover, while the cable may be easily disconnected for testing. As the jointing of the high-tension mains is a somewhat vital part of the circuit, it speaks well for these joints that not one of them has caused the least trouble. At present only four transformer stations are in use. They are equipped with Mordey-Victoria transformers, mostly of the 18-kilowatt size, all of which have been constructed with earthed shields between the primary and secondary windings to satisfy the Board of Trade requirements as to safety. The low-tension network which is fed from these sub-stations serves the principal streets in the town. The length of the low-tension mains at present laid is about 10,000 yards, and the conduit about 15,000 yards.



Raworth and Geipel Joints—Huddersfield

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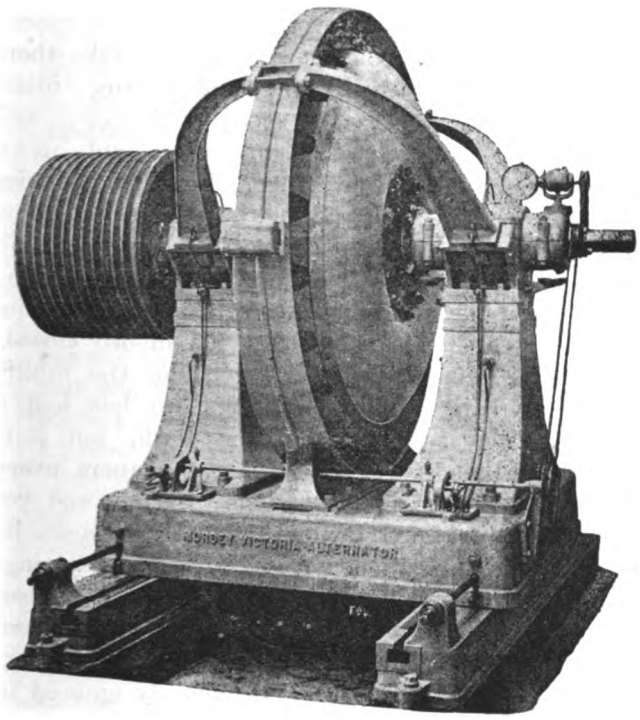
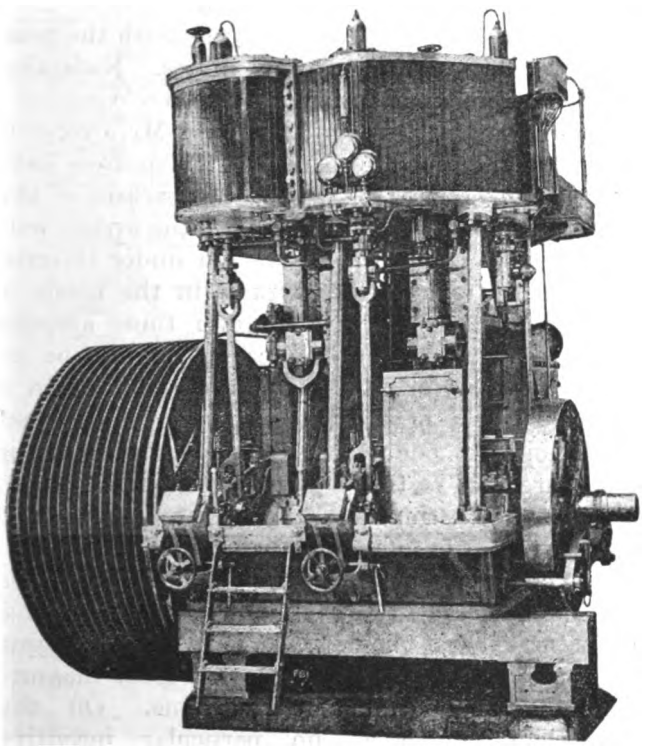
The light has been taken up in a most satisfactory manner; indeed, so great has been the demand that before the station was put to work an order was placed with the Brush Company to double the capacity of the plant in time for this winter's supply. The new plant, which we illustrate, consists of a 250-kilowatt Mordey-Victoria alternator,



Mordey-Victoria Alternator - Huddersfield.

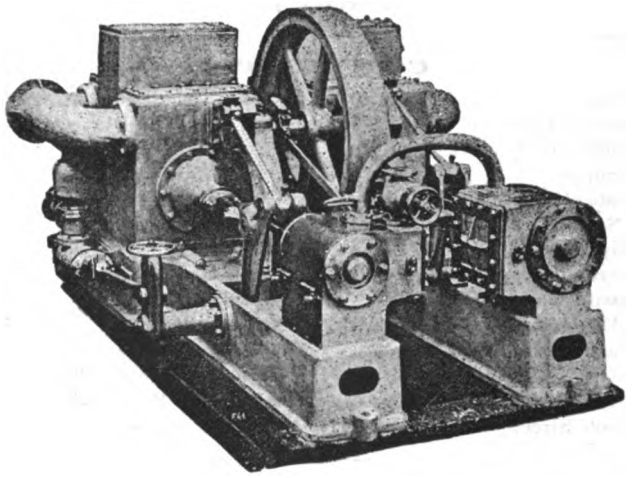
running at 300 revolutions, driven by means of cotton ropes, and a Brush engine, having cylinders 18in. and 33½in. diameter and a stroke of 20in.; it is in most respects similar to the smaller engines already described, and runs at 150 revolutions per minute. A third high-tension main



Vertical Compound Condensing Engine—Huddersfield

is about to be laid to meet the extending demand, and the high-tension mains have already been extended to the residential district up the New North-road. It is interesting to note that the outlying districts in Huddersfield are already being supplied, while in the neighbouring town of Bradford, where the low-tension system alone has been in use several years, the supply is not yet available in the suburbs.

In conclusion, it should be stated that the whole of the works have been carried out under the able supervision (on behalf of the Huddersfield Corporation) of Mr. A. B. Mountain, borough electrical engineer, and generally under the control of the Electric Lighting Committee, the individual members of which have taken the greatest interest in the scheme throughout; while the general design and the equipment of this interesting station has been in charge of the Brush Company's contract department and staff, under the control of Mr. W. Geipel, their superintending

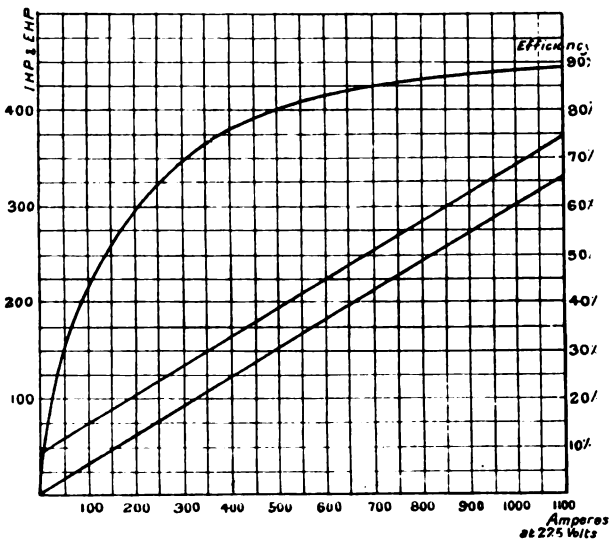


Raworth's Compound Combined Air Circulating and Feed Pumps—Huddersfield

engineer, seconded by Mr. S. A. Mahood as resident engineer.

TESTS OF A SIEMENS-WILLANS SET.

The test of a combined Willans-Siemens set intended for the Glasgow Corporation was recently carried out at the works of Messrs. Willans at Thames Ditton under the supervision of Prof. A. Kennedy, F.R.S. The accompanying table and curve show the remarkable efficiency of



Efficiency Curve, Siemens-Willans Set.

this plant. After allowing the ordinary losses under working conditions, it is difficult to believe that much further advances in efficiency can be obtained. The greatest praise must be given both to the makers of the dynamo and of the engine in having achieved such results.

TEST OF SIEMENS-WILLANS SET FOR GLASGOW CORPORATION.
Siemens dynamo H B 27/40, shunt wound, No. 3,053. Willans engine III, central valve compound, No. 1,533.

Load.	Pressure in steam chest.	Revolutions per minute.	Amperes.	Volts.	I.H.P.	E.H.P.	Water lb. per E.H.P.	Efficiency %
Full	139	346	1,001	225	343	302	23·8	88·04
¾	112	347	740	225	262·2	223·2	27·1	85·11
½	88	344	515	225	197·2	155·3	31·63	78·76
¼	56	345	236·6	225	112·2	71·2	47·9	63·44

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THE

ELECTRICAL ENGINEER.

Published every Friday.

Price Threepence; Post Free, Threepence Halfpenny.

Editorial and Publishing Offices:

39-140, SALISBURY COURT, FLEET STREET, LONDON, E.C.

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ANY LESSONS?

Some patriot in the pride of English achievements is stated to have said we had nothing to learn from the States, and he might have added with equal truthfulness, from anywhere else. Fortunately, these statements—after dinner usually—are here taken for what they are worth, which is not much; but some of our cousins are apt to take them seriously — or, rather, the enterprising interviewer wants to make sensational copy—and circulation is given to something said in a jocular way, or not said at all. Mr. Preece denies that he ever said such a thing, but those who know him had no need of the denial—they always took the statement as far-fetched and improbable. Mr. Preece is a man who has throughout life kept his eyes and ears wide open—and his mouth closed. The latter remark, when we consider the multiplicity of papers and discussions he has had a hand in, may seem wide of the mark, but it is true nevertheless. You may read papers every day and take part in discussions as often, and yet in certain directions for all practical purposes be as silent as the grave. With regard to learning, there is always something to learn, and it is absolutely certain that we have learnt many things from America just as America has learnt many things from us. One great fact is generally ignored in the comparison between the two countries, and that is in the vast difference existing in the conditions which have to be considered. In some of his remarks we do not think Mr. Preece sufficiently took this into account in his paper read last night before the Institution of Electrical Engineers, a portion only of which we are able to give in to-day's issue. In this paper, Mr. Preece sets forth the position of applied electricity in the States. Naturally, somewhat minute attention is given to telegraphy—not more than it deserves; but here Mr. Preece is altogether a critic, and his readers and hearers have little or no chance to make a comparison of the system as holding in the States with the system pertaining in England. Here we are under Government control; there the work is in the hands of private companies. Now, however these systems may be compared, the balance will always be in favour of Government control, especially when a company has a practical monopoly. That is our conclusion, and one of our principal arguments in its favour would be that a gigantic system of land or ocean telegraphy run by a company is too often, if not in every case, run more directly for the benefit of a certain clique of individuals than for the benefit of the shareholders or the community at large. It is but natural that it should be so. Anyhow, the exact position of the company depends in a great measure upon the self-control of this clique. On the other hand, there is no particular incentive upon Government officials to progress. They too frequently say, We have done very well hitherto—why change? The inner working of our postal telegraphs has been different from this, and we can only attribute that difference to the ability and energy of the responsible officials. We are undoubtedly, telegraphically, in a position ahead

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of any other country under the sun. That position, we contend, is in no small measure due to Mr. Preece, whose eyes, ears, and mouth, as we say, have been under control. What he and his colleagues have seen and heard has been carefully tested, and if something else has been adopted, there always seems to be a good reason for it. Take, for example, the use of accumulators *v.* dynamos. The former prevail here, the latter in America; but we venture to think the English officials are correct, and the Americans made a jump in a direction which will have to be changed. Still, admitting our system to be better, there is something to be learnt from American energy and push; and when we look from telegraphy to telephony we are not in the running. Here, as there, the matter has been in the hands of private companies—and who can say that a clique or cliques did not here for years run the system to further their own ends? The subject is a nauseous one—let us leave it. There is, however, one point to which we ought to direct attention—the disturbances caused in telephony by electric traction, and the remedies taken both by telephone and traction companies to prevent it. A little give and take added to a little forbearance will do wonders; but once get the backs of contending parties set up, remedies, of course, are difficult to find. Metallic circuits, on the one hand, and heavier conductors with earthing the negative poles, on the other, have reduced the troubles, and like those arising from electrolytic action, there is no valid reason why traction and telephony should not rest lamb-like side by side. Oh, that we could say like this: "The present generation in America has grown up with the telephone. It has become a factor of business, and absolutely essential to the transaction of that business. The working is excellent, and they are alive to the necessity of maintaining its efficiency at the very highest point. Education is complete not only of the staff, but of the customer. I find a group of highly-educated, clever, young electricians being engaged and encouraged by the telephone companies." Mr. Preece's paper goes on to discourse upon the Chicago Congress, the exhibition, lighting, and traction, and in each direction no doubt we may find something to learn and something to impart. Thus, for example, while we can point to a Siemens-Willans set of electric lighting plant for a central station (Glasgow) giving so high an efficiency as 88 per cent. at full load, it must be admitted that such engines and dynamos are hard to beat. Mr. Preece's statements will be carefully studied, and if points are noted to our disadvantage, no doubt efforts will be made to remedy the remissions, and that we shall allow no one to claim advantages which English practice cannot give. It must not be forgotten that the enormous development both of traction and of lighting in the States is principally due to the peculiar conditions existing. No artificial light and no system of town traction make it easy to introduce either electric lighting or electric traction. It is not too much to say, however, that the Americans are wise in their generation; and though they will take an imperfect system of lighting or traction rather than nothing, and prefer it rather than be kept waiting, they will not be satisfied with the imperfect when better can be obtained. Thus the rapid progress made—they take the best they can get, and ask for something better, which they take as soon as they can get.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

ENGLISH CARBONS.

SIR,—Our attention having been drawn to a statement made in several of the electrical newspapers that "all carbons used in England for arc lighting have hitherto been imported from abroad," we should be obliged if you would correct this statement, which is inaccurate.

We have been engaged for over 15 years in the manufacture of carbon rods for electric lighting. These carbons have been made under English patents, and at our works at Silvertown we have a complete plant in daily operation for the production of such carbons for electric lighting.

We trust that you will insert this contradiction in an early issue.—Yours, etc.,

WM. J. TYLER, Secretary.

India Rubber, Gutta Percha, and Telegraph Works Company, Limited, 106, Cannon-street, London, E.C., January 22, 1894.

INSTITUTION OF ELECTRICAL ENGINEERS, Jan. 25.

At last night's meeting of the Institution, the following candidates were ballotted for:

Foreign Members.—Oscar Bihet, director of the Société St. Leonard (Outils), 1, Rue St. Leonard, Liége; Samuel G. Neiler, Chicago, Illinois, U.S.A.; Richard Henry Pierce, Chicago, U.S.A.

Associates.—Henry John Andrews, 184, Iverson-road, West Hampstead, N.W.; Philip Francis Anstruther, Fernando de Noronha, Brazil; Frank Ayrton, Preston Villa, Otter-street, Tristis Park, Derby; H. Brookes-Edwards, Cardigan Works, Wakefield, Yorkshire; Cox Pearson Chambers, superintendent Government Telephones, Antigua, Leeward Islands, British West Indies; William Challoner, Blackpool; George Granville Clarke, 6, Smith-square, Westminster; William Henry Eaves, Volt Works, Ryley-street, Coventry; Augustus Eckstein, 45, Chapel-street, Salford; Michael Birt Field, Claremont, Woodberry Down, N.; Charles Lewis French, 46, Bayston road, Stoke Newington; John Grant, inspector Government Telegraphs, Cape Town, S.A.; C. J. Whistler Hanson, 16, Featherstone-buildings, Holborn, W.C.; W. Marshall-Huskisson, 127, Ladbrooke-grove, W.; William John Kelly, 58, Bread-street, E.C.; John William Leyshon, 32A, Lower Cathedral-road, Cardiff; Alfred Marshall, 31, Ball-street, Kensington; Alfred Ernest Le Rossignol, Alton Cottage, Mount-street, Old Charlton, Kent; Thomas William Skinner, 6, Carlton House-terrace, London; Frank H. Starling, 35, Queen's-walk, Nottingham.

Students.—Gerald Carlyle Allingham, Eldon House, Lyndhurst-road, Hampstead, N.W.; Frank Armstrong, Faraday House, Charing Cross-road, W.C.; Walter James Belsey, "Clarville," Albany-road, Chorlton-cum-Hardy, Manchester; James Herbert Edwards, Faraday House, Charing Cross-road, W.C.; William R. Elliott, City and Guilds Technical College, Leonard-street, Finsbury; Louis Henry Euler, Faraday House, Charing Cross-road, W.C; William Fennell, 1, Ferndale-road, Leytonstone, E.; Herbert Francis Hunt, 14, Thistlewaite-road, Clapton, N.E.; Lionel C. Johnson, 13, Lorn-street, Chorlton-on-Medlock, Manchester; Albert Henry Joyner, 26, Dorothy-road, Clapham Junction, S.W.; Philip E. Lewis, 3, Tetcott-road, King's-road, Chelsea; W. M. Nelson, 18, Pyrland-road, Canonbury, N.; William Samuel Parsons, Faraday House, Charing Cross-road, W.C.; Eliot Charles Pringle, Faraday House, Charing Cross-road, W.C.; John Thomas Redmayne, 71, Albion-street, Leeds; Charles Alfred Spon, 125, Strand, W.C.; Frederick William Baron de Tuyll, 51, Earl's Court-square, W.

The following paper was then read:

NOTES OF A TRIP TO THE UNITED STATES AND TO CHICAGO, 1893.

BY W. H. PREECE, C.B., F.R.S., PAST-PRESIDENT.

In 1877, together with Mr. H. C. Fischer, I made an officia and thorough inspection of the telegraphic system of the United States and Canada, and the lessons of that journey were re-

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ported to this Institution on February 13, 1878. The results of that trip were the introduction of the telephone, the practical application of quadruplex working, the adoption of sound reading in our telegraph offices, the disappearance of the Morse recorder, and the more general assimilation of the methods of working in the two countries. In 1884, as a member of the British Association, I again visited Canada, and made another tour through the States, reporting my observations to the Institution on December 11, 1884. The chief result of this second trip was the introduction of the multiplex system of working of Mr. Delany, now so much in use amongst us, and doing splendid service with many of our chief towns; hexode working, six messages in any direction are simultaneously transmitted between London, Brighton, Bristol, Birmingham, and other commercial centres. The telephone was found fully developed, and firmly rooted as an invaluable aid in domestic and business requirements. The electric light was making great advances, especially as the illuminant of public streets and ways, to the great advantage and safety of the public, but electric railways and the transmission of power were only just looming in the air in an extremely tentative and experimental stage. Now I am able to report another tale of a 10 weeks' trip taken in August and September last over much the same ground, but with two *pièces de résistance* thrown in—a visit to the great World's Fair, and the holding of an electrical congress at Chicago.

I. Telegraphs.

The telegraphic system in the United States is in the hands of two great private telegraph companies—the Western Union Telegraph Company and the Postal Telegraph Company. The Western Union Telegraph Company, which is by far the larger of the two, is a gigantic undertaking. It is a congerie of at least 500 other companies which have been purchased, absorbed, or amalgamated from time, and it is also closely connected with virtually all the railways in the States. This connection with the railway companies gives it a very prominent and commanding position over its rival. In order to show the progress made since 1884, and the present condition of the business, I give the following table:

Particulars.	1884.	1893.	Great Britain, 1892.
Miles of poles and cables	145,037 ..	189,936 ...	33 689
Miles of wire..... ...	450,571 ...	769,201 ...	207,231
Offices	13,761 ...	21,078 ...	8,537
Messages	42,076,226 ...	66,591,858 .	72,302,556
Capital	$80,000,000 ..	$123,000,000 . .	£10,130,820
Receipts.....	$19,632 940 ...	$24,978,442 . .	£2,486,791
Expenses	$13,022,504 ...	$17,482,405 ...	£2,470,839

The Postal Telegraph Company is a very much smaller concern. It has virtually come into existence since my previous visit, for when I was last in the States it had just commenced its operations, and it only possessed 1,500 miles of line and 4,260 miles of wires. It is a company which has been promoted, not so much to attack the Western Union Company, as was the case with all previous competing lines, but to establish a collecting company for the cable business which is in the hands of the Commercial Cable Company. The present position of the Postal Telegraph Company is as follows: Miles of line, 15,997; miles of wire, 99,664; offices, 2,664 (of this number 860, or nearly one-third, are situated out of the States, in Canada and elsewhere); messages, 9,335,291. The enterprise in telegraph work is evident at once on landing in New York. Every passenger on landing at the dock stage is approached by a messenger from one or both companies soliciting messages; and on all stages, except that of the Cunard Company, one or other of the telegraph companies has succeeded in establishing an office. The business done at these offices is very great, as, when facilities are thus given to passengers to send messages, nearly everyone wires home his or her safe arrival. This enterprise is evident everywhere. The blue and white sign of the Western Union Company, which is extremely prominent, is found in every hotel, at all railway stations, and in large cities, and is as abundant as the post office sign is in England. At Long Branch, the Brighton of New York, where I spent two or three very pleasant days, there were no less than 19 offices belonging to the Western Union Company, and all paying. There were 20 offices in the World's Fair alone, and 70 hotels in Chicago have Western Union offices in them. Competition is intense, but there is no war of rates. A general tariff has been agreed upon, and the only rivalry that exists is in the collection and transaction of business. Dividend-earning being the chief end aimed at, only paying commercial stations are properly served. Social and domestic telegraphy is practically ignored, and sparsely-populated districts are very inadequately provided for. Hence in the United States telegraph business is neither so general nor so cheap as it is with us. The average price received per message is 15¾d., as against 7·7d. earned by us. On the other hand, however, it must be remembered that their mean distance is far in excess of ours.

Construction of Lines.—I inspected considerable lengths of the line work constructed by each company, and drove over many miles of a new road line passing through Connecticut. In this direction American electrical engineers have been very much behind us. They have not built their lines so solidly, nor have they followed true engineering principles in the same way that we have. As a rule, their lines are extremely irregular, being badly constructed with poles that we in England would not look at; but recently, owing to the difficulty in finding fresh routes, the growth of the number of the wires, and to the absolute necessity for accuracy of workmanship for securing silence on telephone lines, great improvements have been made, and some of the trunk lines put up by the telephone companies, and the new trunk line put up by the Postal Telegraph Company, will compare very favourably with our best modes of construction. The telephone line to which I have alluded above consists of 16 arms, each carrying 10 wires, or 160 wires in all. The poles are 60ft. high, and are placed 100ft. apart. The arms are of pine, and their scantling is 3½in. by 4½in., and they are 10ft. long. Owing to the use of wooden pins they are bored with holes 1½in. in diameter. This weakens the arm, and I observed two instances where arms were broken. A 6ft. arm bored for four insulators costs 15 cents, which is cheap compared with the price we pay. But they are undoubtedly weak, and not to be compared with the oak arms that we use. As a rule, the poles number 40 to the mile. They are generally of cedar, but sometimes of chestnut. The cedar poles come from Canada and Michigan. Each 25ft. cedar pole costs 2·25dol., and is said to last 15 years without preparation. The chestnut pole is a little cheaper, and it lasts only 10 years. It is extremely irregular in shape. American engineers do not adopt the same plan that we adopt in the erection of arms. They are fixed any way, but generally on the modern lines they alternate on each side of the pole. This is done under the impression that it adds strength to the line. I do not know why it should. (We invariably fix the arms on that side of the pole facing London.) Every fifth pole is earthed as a protection against lightning. (We earth-wire every pole.) Stays are very little used, indeed, but on new lines they have longitudinal stays in the direction of the wires, one end being fixed at the foot of one pole, and the other end at the top of the next pole. These are called "head guys," and are frequent. Iron poles are used only for electric railways. These are very substantial, and look very well. They are made in three sections of simple iron tubes, either 6, 5, and 4, or 5, 4, and 3 inches in diameter respectively. Pole roofs are not used as with us, but the poles are tapered off to throw off the rain. Neither the Western Union nor the Postal Telegraph Company adopt any system for preparing their timber to resist decay. My attention had been called to a system of artificial seasoning called "wood vulcanising," and it was reported that this system had been adopted by the Western Union Company. I found this was not true. The Western Union Company had experimentally tried the system on some wooden troughing employed for the protection of their pneumatic tubes underground; but the process was so expensive, and the advantages so doubtful, that they do not apply it to their poles or their arms. Copper wire is very much used on telegraph and telephone lines. I saw in the exhibition at Chicago a form of wire called "tempered copper." This is said to be extremely strong and hard, but it is evidently an alloy of copper, for its resistance is high. I was surprised to find that a compound wire 1·7 ohms resistance per mile, put up by the Postal Telegraph Company in 1883, is still in use, and working well. Our experience of the durability of this wire was disastrous.

Underground Work.—Underground work was scarcely started in the States in 1884, but now, owing to peremptory legislation on the part of the municipalities, it has made very rapid progress. Underground work in the cities of the States has become general, with great advantage to the public, and also, as they have come to acknowledge, to the companies themselves. The only exception to this rule that I heard of was at Boston, where complaint was made that their underground system had been much disturbed by "wash-outs." These "wash-outs" are freshets, or great floods, tearing up the line and carrying away the pipes and wires. The system of underground work adopted by the telegraph companies in America does not differ much from that adopted by us, excepting that they do not use gutta-percha, owing to its high price. They are using very largely a cable similar to the Fowler-Waring cables, and also kerite-covered wire. Kerite is a form of vulcanised indiarubber.

Offices.—Not much change has been effected in the mode of fitting up offices. Glass of the best quality is used very much indeed—doors, partitions, boxes for the collection of messages, are all made of thick glass. This looks very clean and nice, and is certainly effective. There is an extremely efficient mode of collecting and distributing messages in the Western Union offices at New York and Chicago. Endless cords are kept in motion by means of small electric motors, and these cords transport small metal carriers somewhat similar to those we use in our pneumatic tubes. Before leaving New York I saw an improvement on this by which messages can be picked up as by the finger and thumb from the desk in front of each operator. They also have in use a system by which

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messages, envelopes, slips, etc., are conveyed by broad continuous leather belts, 8in. wide, kept in rapid motion by motors, and upon which the messages, etc., are laid, and carried to the point desired. Each company has adopted a uniform and pretty-looking box for its office in the hotels. American hotels differ from ours in this: the hall of an hotel is usually open to the public, and no hotel that I entered was unfurnished with a telegraph office. I have mentioned that there were 70 hotel offices in Chicago. In fact, hotel proprietors court the presence of a telegraph office. Space is usually accorded free, and board is also provided for the operator. In some places, like the Palmer House Hotel, at Chicago, which is a great business centre, a very high rent is demanded; but generally speaking no rent at all is paid. At the hotel I stayed at in Chicago—the Lexington—each company had an office in the hall, the rivalry that exists between the two companies taking the form of each striving to work with the louder sounder. The louder was that of the Postal Telegraph Company, and when I asked the operator why he allowed his instrument to make such a row, he replied, "We must beat the Western Union Company, anyhow." At Fort Sheridan, a military station about 20 miles away from Chicago, the Western Union Company opened an office, although the place contained only 1,000 soldiers. The office was worked by the soldiers, and I was assured by the company that they found it pay well. The common system in the States is to tile the floors of their telegraph galleries, and not to board them. Fireproof channels, or conduits fitted with slate tops, are arranged about the office for the distribution of the wires. Lockers for coats and hats are roomy and well made, and ample in the supply. At Chicago they are of open ironwork, very neatly made, 6ft. 6in. high, and 28in. by 8in. in sectional area. Four men, each of whom is supplied with a key, use such a locker. Great advantage is said to arise from the use of these open lockers in wet weather, and they are worth our own consideration. The use of bicycles for messengers is very prevalent in the States. Batteries at all the principal offices in the United States are gradually disappearing. The current for working the circuits is being supplied from dynamos, or from the electric lighting mains. In New York from 30,000 to 40,000 cells have been replaced by dynamos. At Boston 10,000 cells, which cost probably £4,000 per annum to maintain, have been replaced by current derived from the electric light mains at a cost of £600 a year. It must be remembered that the American telegraph circuits are worked entirely on the closed-circuit system. They use immense cells, and their cost of maintenance is excessive. We cannot compare their system with ours in this respect, for we use open circuits; and the maintenance of our batteries is certainly, cell for cell, not more than one-fourth or one-fifth that of the United States form of battery. In New York, the Western Union Company have a special plant of 51 small dynamos; in Chicago, they have 46. The Postal Telegraph Company in New York are also using dynamos, and in their new station which is being built they are supplying what they believe to be an improvement on the system adopted by the Western Union Company. We have shown in England that the use of dynamos, owing to the variation of current, is not suitable for high-speed working, and I much prefer the plan that we have adopted with so much success in working our continental circuits—namely, the use of accumulators. Accumulators have an immense advantage over dynamos: they store up energy, so that in the event of any accident or breakdown of machinery the accumulator maintains the circuits working. The accumulator is not in motion. There is no machinery to fail or to break. There is nothing to stop and little to get out of order. But the chief advantage of the accumulator is the absolute steadiness of its voltage. There is also economy in capital expenditure, and I am quite convinced that the Western Union Company in New York would have effected considerable economy if they had used accumulators charged by the electric lighting plant, instead of supplying the elaborate series of engines and dynamos now working their circuits direct. At Boston and other stations a very well-made and well-designed motor-dynamo is supplied by Messrs. Crocker-Wheeler. They are primarily motors worked on the 110-volt electric lighting service, driving a small dynamo, and they transform this down to a voltage which will charge any number of cells required. This system is in use by all the telephone companies, and, as I will point out when speaking of telephones, the service is much improved by the use of accumulators thus charged.

Apparatus.—I observed little or no progress in the form of apparatus used. In neither company has there been any advance made on the systems in use in 1884. Duplex and quadruplex working are principally relied upon, while on the long-distance lines Wheatstone working is gaining ground and being much more used. The only novel mode of working that was brought to my attention was a system of working cables automatically. This system has been threshed out by Mr. Wilmot at Waterville, and adopted by the Commercial Cable Company, but it has been very much improved upon by Mr. Delany, the inventor of our multiplex system. Typewriters have become quite common. The rule is for an operator to have his own machine. The Postal Telegraph Company use this system more largely than the Western Union Company. The latter company employ it invariably for their Wheatstone and other news circuits, but the Postal Telegraph Company use it very largely on all circuits; and I watched many operators taking off messages by ear and typeprinting them at the same time, and in all cases the typewriting machine held the sounder well in hand as regards speed. The working of the Wheatstone system between New York and Chicago is admirable. The grand total of messages handled in one day on this circuit is certainly astonishing; 4,211 messages have been passed between these two places on one circuit in a day—a number that we can scarcely hope to rival. The reason for this is not the greater speed at which the apparatus is worked—for the speed is less than ours—but to the fact that the business day in the United States extends over a much greater number of hours than with us. The business day in New York commences three hours before that in San Francisco, and the business day in San Francisco extends for three hours beyond the business day in New York. Hence the business day, which in England scarcely extends telegraphically to four hours, in the United States extends probably to 12 hours. Thus the number of messages handled is much greater per day than with us. The advantage of Wheatstone working to the company was illustrated while I was there. On August 29 a cyclone in the eastern part of the States prostrated the poles and wires for miles throughout half-a-dozen States. Three Wheatstone circuits were maintained working—and working badly—between Chicago and New York by means of repeaters at Buffalo and Pittsburg, but on these three circuits 8,693 messages were handled. This was the only means of telegraphic communication between the Eastern and the Western States. Curiously enough, the new and strong long-distance telephone line was not broken down. On August 18, while I was there, I took down as having been sent between 8 a.m. and 5.30 p.m.: forwarded, 1,272; received, 1,889. This work was handled on two circuits, with an average speed of 190 words per minute. The Wheatstone system in the States is much more extensive in the West than in the East. It is giving such good service that it will probably receive considerable additions this year. It must be remembered that between Chicago and San Francisco we are dealing with a distance of 2,500 miles, and on this circuit they were working when I was there at the rate of 110 words per minute. I observed a very high rate of working on some of the quadruplex circuits. I took down these figures at Boston: forwarded, 686; received, 521. This was an ordinary day's work. On another circuit, between 8.30 a.m. and 11.30 a.m., in Buffalo, the numbers were: forwarded, 126; received, 140; on one side of the quadruplex only. I noticed at the Chicago Exhibition, in the French exhibit, a new adaptation of multiplex working by M. Mercadier, who showed in operation 12 working sides. But the working, although interesting, was poor. The reading was done by telephone, and each branch was selected by the sounding of a particular note. The apparatus is not yet in anything approaching a practical stage, but for short lines something may some day come out of it.

Pneumatic Tubes.—The Western Union Company have not extended their system of pneumatic tubes greatly since my last visit. The Postal Telegraph Company are about to use pneumatic tubes for the distribution of their internal work in their new building on a plan somewhat similar to that which we use at our central station. The only novelty in pneumatic tubes that I saw was that on trial between the post office at Philadelphia and a sub-office in Chestnut-street. This is a line of two pipes 6⅛in. in diameter and 5,792ft. in total length—that is, a distance between the two offices of 2,896ft. The carriers are metal cylinders, whose inside dimensions are 16in. long and 5½in. in diameter. They weigh 6lb. each, and carry 120 letters. The carrying capacity of the line is said to be 180,000 letters per hour, but I think this is exaggerated. The time taken by a carrier in transit is 55 seconds, and the air pressure is maintained at 7lb. per square inch. The line has been working since February 17, and it has been used for the transmission of letters, the whole service to this particular sub-office being done through the pipe. The pipe is continuous, and a current of air is constantly flowing through it. Twenty-five horse-power is absorbed in maintaining this current at the pressure required, and the carriers are said to move at the rate of 40 miles an hour. Twenty-five carriers are in use. Unfortunately, while I was there the tube was out of use, for the boilers had broken down. These boilers belong to the Post Office Administration, and were not under the control of the contractors who are carrying out the experiment. It is merely an experiment, but it is an experiment that has been carried out in a very practical manner, and they are threshing out a question that may be of importance. They find that the tube used is too small for their purposes, and they are going to use in future an 8in. tube.

Distribution of Time.—A feature of considerable interest and novelty is the distribution of time by the Western Union Com-

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pany. Correct time is received every day at noon from Washington. The time-current lasts one second. Time-balls are dropped at Boston, Newport, Woods' Holl, New York, Philadelphia, Baltimore, Washington, Fortress Monroe, Savannah, New Orleans, and Havanna. This current is also distributed by the Western Union Company to subscribers in the principal centres. In New York there are 1,100 subscribers, in Chicago there are 1,837, while in the whole of the western district of the company there are 7,963 subscribers. Each of these subscribers has a special wire upon which the time currents are sent from a master or a controlling clock. The Western Union Company also furnish synchronous self-winding clocks to the subscribers, which are controlled and regulated daily by these time-signal currents. They are wound automatically every hour. The rates for this service are not excessive. Each subscriber is charged 2½dol. per month, while large buildings using five or more clocks get the time signal supplied at 1¼dol. per clock per month. The standard time adopted in 1883 is virtually Greenwich time. It is divided into four sections. The following table will show how far these differ from Greenwich mean time and from each other :

W. long.	Centre.	Actual time.	Name adopted.
0deg.	Navigators' time (Greenwich)	noon	Greenwich time.
75deg.	Washington meridian	7 a.m.	Eastern time.
90deg.	Chicago meridian	6 a.m.	Central time.
105deg.	Denver meridian	5 a.m.	Mountain time.
120deg.	San Francisco	4 a.m.	Pacific time.

Thus the minutes and the seconds are the same as with us. There is no necessity to alter one's watch. Hefner von Alteneck proposes to place clocks in the circuit of an ordinary incandescent lamp, and to wind and control them by a slight change in the current made at the central station once a day. It is surprising what can be done by electricity when it is laid on in a house and served from a central station. Von Alteneck's system was exhibited at the World's Fair.

Conclusions.—It is quite impossible to inspect the telegraph system of the United States and compare it with our own system without drawing comparisons between the way in which the work is done in the two countries. The result of my previous visit was to confirm my view that we do our work better in England than they do in the States. Our apparatus is better, our speed is higher. Messages are handled with greater reliability. A message can be sent and its reply received with certainty in an hour in England. I fancy such rapidity would astonish the users of the telegraph in the States, except those in such busy centres as New York and Chicago, and generally the speculative branches of the community. The domestic telegram scarcely seems to have reached the United States, and this is owing probably to the fact that the districts of private residences, the small towns, and the villages do not possess telegraph offices, unless they are supplied by the railway company at the railway station, or by the Western Union Company, who do the work for the railway company. I fail to see any superiority in the manipulative skill of American operators. They certainly have not made the same advance in technical education that we have, and altogether it may be said that the management of the telegraphs in the States in the hands of private enterprise does not compare favourably with the management of the telegraphs by the State at home. At the same time it must not be assumed, because the Government have advantageously taken the telegraphs in hand at home, that such a process would be possible in the States. In my opinion, it would be absolutely impossible. The Civil Service of the States is in a very chaotic condition. The principal appointments are four-year appointments only, and are filled politically. The principal postmasters come in and go out with each new president. We in England scarcely consider that a postmaster is fit to be a postmaster until he has had many years' experience of the working of the Post Office system. In the States a man is made a postmaster because he has been a political supporter. At one or two offices I found the new Post Office officials absolutely ignorant of simple facts they ought to have had at their fingers' ends. A business like that of telephones or telegraphs can only be conducted properly by those who possess a considerable amount of enterprise, and who look primarily to the necessities of the community. The reason why our post offices and our telegraph offices at home work so well is because the public exercises such a useful and such a determined supervision over the work. The free opening of the Press to complaints; the readiness with which members of the House of Commons ask questions—though at times, perhaps, irritating and vexatious—are undoubtedly good for the service, for they keep us all alive. Such a state of affairs is impossible in the States. The Government of the United States must first reform its Civil Service, and when it gets officials into the service whose tenure of office is secure, and whose zeal is as unquestioned as it is in England, then there will be some chance of their Government acquiring the telegraphs; but under existing circumstances the acquisition of the telegraphs by the Government of the United States would amount virtually to the deterioration of the service. The commercial management is at present, as I have pointed out, characterised by great energy. I do not, however, acknowledge that they show greater energy than we do in England. Competition may make it more conspicuous, but it is not more reaching. Our speculative business, stocks, and racing is done as well as theirs. The management at home is characterised in all particulars with similar energy to that which I observed in the States; and I come back without any views or wrinkles which I think could be impressed with advantage on the commercial or technical management of our system at home, unless it be the encouragement of offices in hotels, for it is found everywhere that a telegraph office at one's door prompts the desire or want to telegraph. The capital of the Western Union Telegraph Company was in 1877 22,000,000dol.; that of the British Post Office was £10,000,000. The capital of the former is now 123,000,000dol., while that of the latter remains virtually the same. Scarcely a single vestige of the old telegraph companies' systems purchased by the State in this country now remains. Whence, therefore, this splendid system of cables, underground lines, and new pole lines in this country, spreading everywhere, and transacting an annual business of £2,500,000, instead of the £600,000 handed over to us? It has all been paid for out of revenue! The Government keeps no capital account. How do we do our work? The proof of the pudding is in the eating thereof. The criterion of telegraph-working is rapid despatch. "Time is our only competitor," said Dr. Norvin Green. The time occupied in its transit from the hands of the sender to those of the receiver is the pudding. The whole of the messages arriving in Newcastle on the morning of January 20 were examined and analysed. The mean time of transit from all parts of the United Kingdom averaged 7·8 minutes. A similar examination at Glasgow on January 15 gave a mean result of 8·7 minutes. This cannot be beaten, and it certainly will not be believed. The late Mr. Patey was once asked why express telegraph service at higher rates was not introduced in England. His answer was: "All our messages are express already."

II. Telephones.

The business of telephony in the United States has made gigantic strides since I visited that country in 1884. The following table will show the position of the industry then and now :

	1884.	1893 (January 1).
Miles of wire	115,255	440,793
Miles of underground wire	Nil	91,463
Telephones in use	325,574	552,720*
Telephone subscribers	123,625	232,140
Number of connections between subscribers and exchange	215 millions	600 millions (est.)
Telephone exchanges	1,325	1,351
Staff employed	4,762	9,970

* This is the total number of transmitters and receivers. According to our system of reckoning, where the two together are considered as one instrument, the number given should be divided by two. Thus for comparative purposes it may be said that the United States has 276,360 telephones in use.

It will be seen that there is a very small increase in the number of exchanges opened. This is owing to the fact that hitherto there has been a tendency to centralise the exchange work, and while many exchanges have been abandoned, the small increase is due to the fact that many new exchanges have been opened. It will also be noticed that in the States they have gone in very largely for underground work. This has been forced upon them by municipal action. In addition to this, the companies themselves have been compelled by the indifferent working of their systems to fall back upon the metallic circuit, and now there are 23,053 metallic circuits in use. In New York 62 per cent. of the circuits are metallic, in Buffalo 77·84 per cent, in Boston over 50 per cent., in Chicago 20 per cent., and in Brooklyn 60 per cent. The business of telephony in the United States is a gigantic monopoly in the hands of the American Bell Telephone Company, whose headquarters are at Boston. This company owns more than one half the stock in every telephone company in the States. It holds itself the whole of the stock of what is commonly known as the Long-Distance Telephone Company, but which is really entitled the American Telephone and Telegraph Company, and thus by having control of the stock in every company it maintains the power and monopoly. The advantage of this monopoly is the establishment of a uniformity of working and practice that is highly and extremely beneficial. The form of apparatus used, the mode of working, the details of construction, and all the methods in use are dictated from Boston. The result is little or no friction; and while each independent company is self-managed and self-contained, nevertheless it is subservient to the direction and control of headquarters at Boston. There is no divided responsibility in the United States. Every town has but one system. The result is that the service is thoroughly and perfectly performed. In those parts of the country where metallic circuits have not yet been adopted there may be defects in working, but these are rapidly being removed, for the benefit

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derived from metallic-circuit working is being felt everywhere in the United States.

Exchanges.—The modes of working may be divided into three classes: (*a*) That dealing with local subscribers alone working upon a single exchange; (*b*) that dealing with trunk working between exchanges in one town or district; and (*c*) that dealing with long-distance speaking, such as that between New York and Boston, New York and Philadelphia, New York and Chicago. I visited three exchanges at Chicago, one at Buffalo, one at Boston, and three in New York, and I looked very thoroughly into the working of each system. While I did not think that any of their local working is done any better than, if as well as, the local working on our own exchange at Newcastle-on-Tyne, there is no doubt that in their trunk working, both for inter-exchange communication and for long-distance working, they are far ahead of us in England. The prevailing switch in the United States is the multiple board, made by the Western Electric Manufacturing Company. The largest board in the world is one which I carefully examined at the Cortlandt-street Central Exchange in New York. It has a capacity for 6,000 subscribers; it is 263ft. long, and is divided into 40 sections. One operator handles 60 subscribers. There are 260,000 holes, or "jacks," as they are called in the States, while in fitting up this switch 780,000 soldered joints were made. It is found in the States that multiple boards can become too large, too unwieldy, and they introduce troubles of their own that have to be remedied. These defects are aggravated when there are several exchanges in the same city. In Chicago Main Exchange 25 per cent. of the business, in Harrison-street Exchange 94 per cent., is trunked out. The average trunking is 50 per cent. A multiple board is, therefore, useful for only 50 per cent. of the work done.

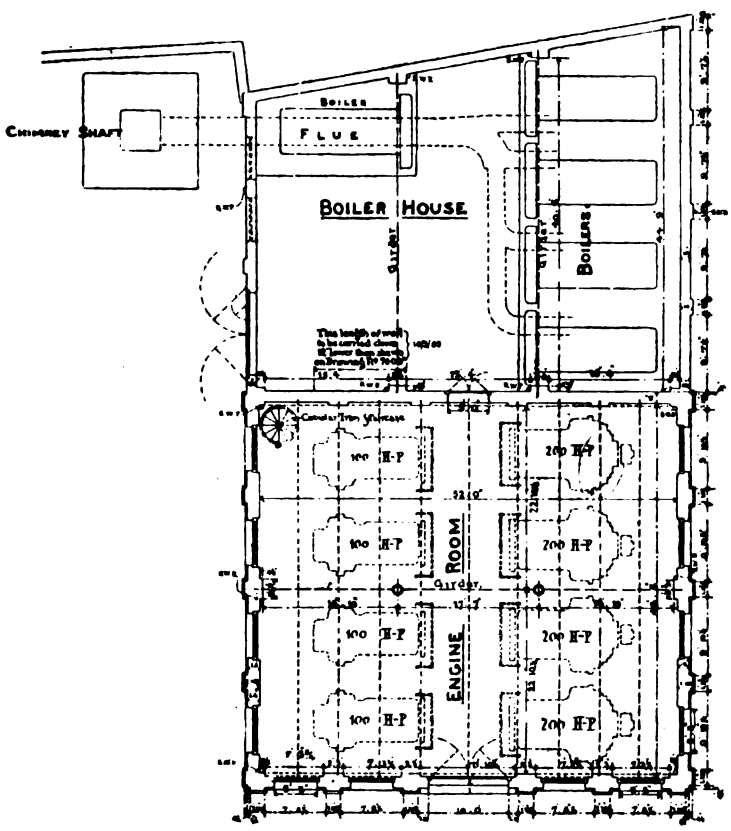
(*To be continued.*)

THE ELECTRIC LIGHT INSTALLATION AT GREAT EASTERN RAILWAY TERMINUS, LIVERPOOL STREET.

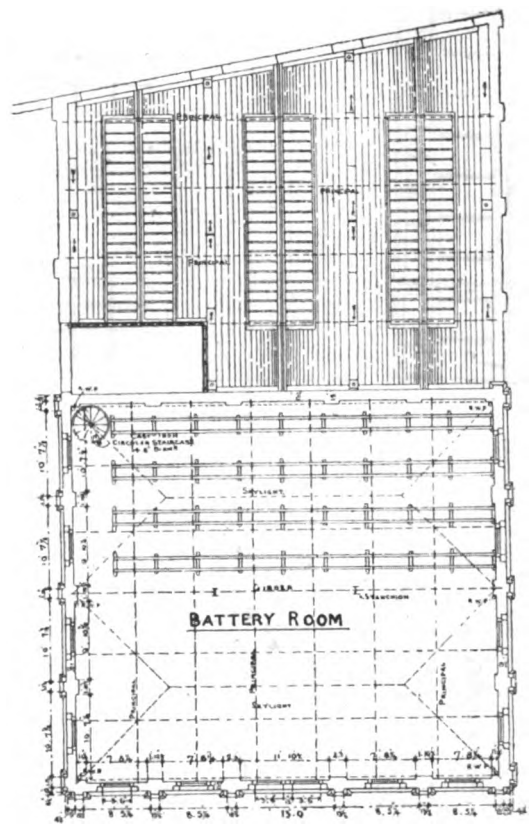
The arc lamp is by no means a stranger to the frequenters of Liverpool-street Station; indeed, the platforms have been lighted by electricity for some years with success and economy.

The enormous extensions that are in process of being carried out on the area of land between the old station and Bishopsgate street Without (practically amounting to an increase of the terminus capacity and space by 100 per cent.) has necessitated a complete remodelling of the electric lighting plant, with an even greater increase in its output; and a special building has been erected just outside the station to accommodate boilers, engines, and dynamos.

This new erection—as may be seen from the annexed illustrations — is of a very complete and extensive character—large enough, in fact, to suffice for a small town, the total capacity being not less than 1,200 h.p. in an area of 90ft. by 50ft. It stands fronting the main street, just at the point where the Great Eastern Company's main lines pass underneath the roadway at an angle near the junction of Norton Folgate and Shoreditch. It is built partly on a triangular plot of land at the ground-level, and partly on the railway arches themselves. The building is of red brick faced with stone, and presents a very handsome appearance from the roadway. The front of the engine-room abuts upon the pavement of Norton Folgate, and has massive entrance doors in the centre.



Ground Plan



First Floor Plan

G. E. R. Electric Light Installation—Buildings.

The steam-engines employed are eight in number—four of 200 i.h.p. each, and four also of half that capacity. They are of the inverted vertical compound type, coupled direct to dynamo generators of Crompton and Co.'s make. The engines are by Davey, Paxman, and Co., who also have provided the boilers—five in number—of which only four at present are erected. The boilers are of the Lancashire type, with mechanical stokers, and underground flues leading into the base of a large brick chimney stack just outside, 150ft. high.

The engine-room has a height of 20ft. clear to the ceiling, and is provided in each of its two bays with light steel rails on a bracket gauntry way for an overhead travelling crane, by which the heavy parts of engines or dynamos are lifted as required.

On the first floor, above the engine-room, is a chamber of equal area intended for use as an accumulator-room, and approached from below by means of a circular iron staircase. The roof of this room, and also of the boiler-

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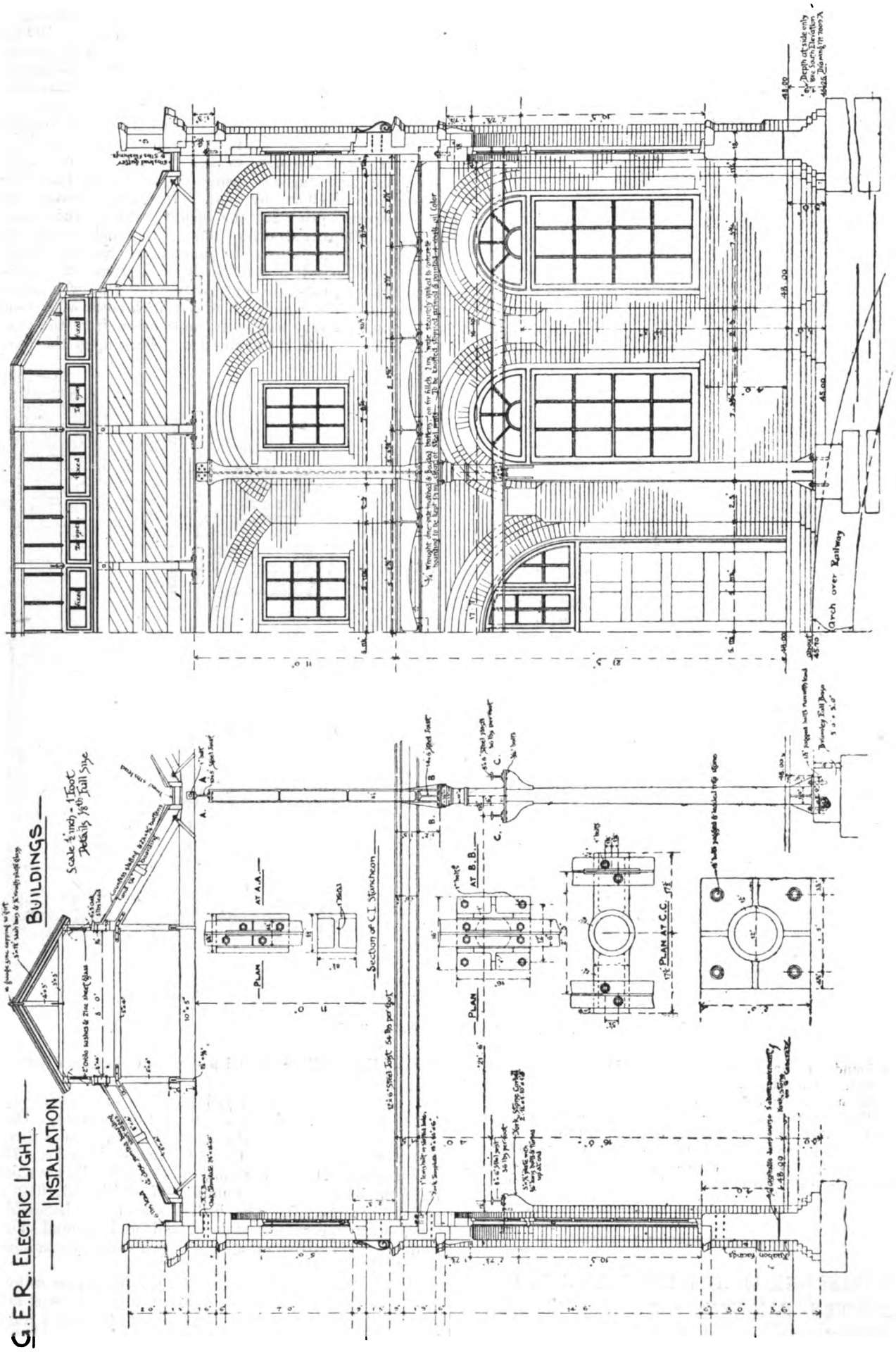
house, is provided with adjustable louvre ventilators to allow the escape of smoke, heat, and fumes. As shown in the drawings, two cross-lattice girders, 3ft. 3in. deep, serve to sustain the boiler-house roof.

The current from the main switchboards—which occupy nearly all one side of the engine-room—is led along the railway lines to the station, where a large number of arc lamps light up the 17 platforms (involving nearly six miles of track), also the station halls and large areas. Then a great many incandescent lights are installed in the station



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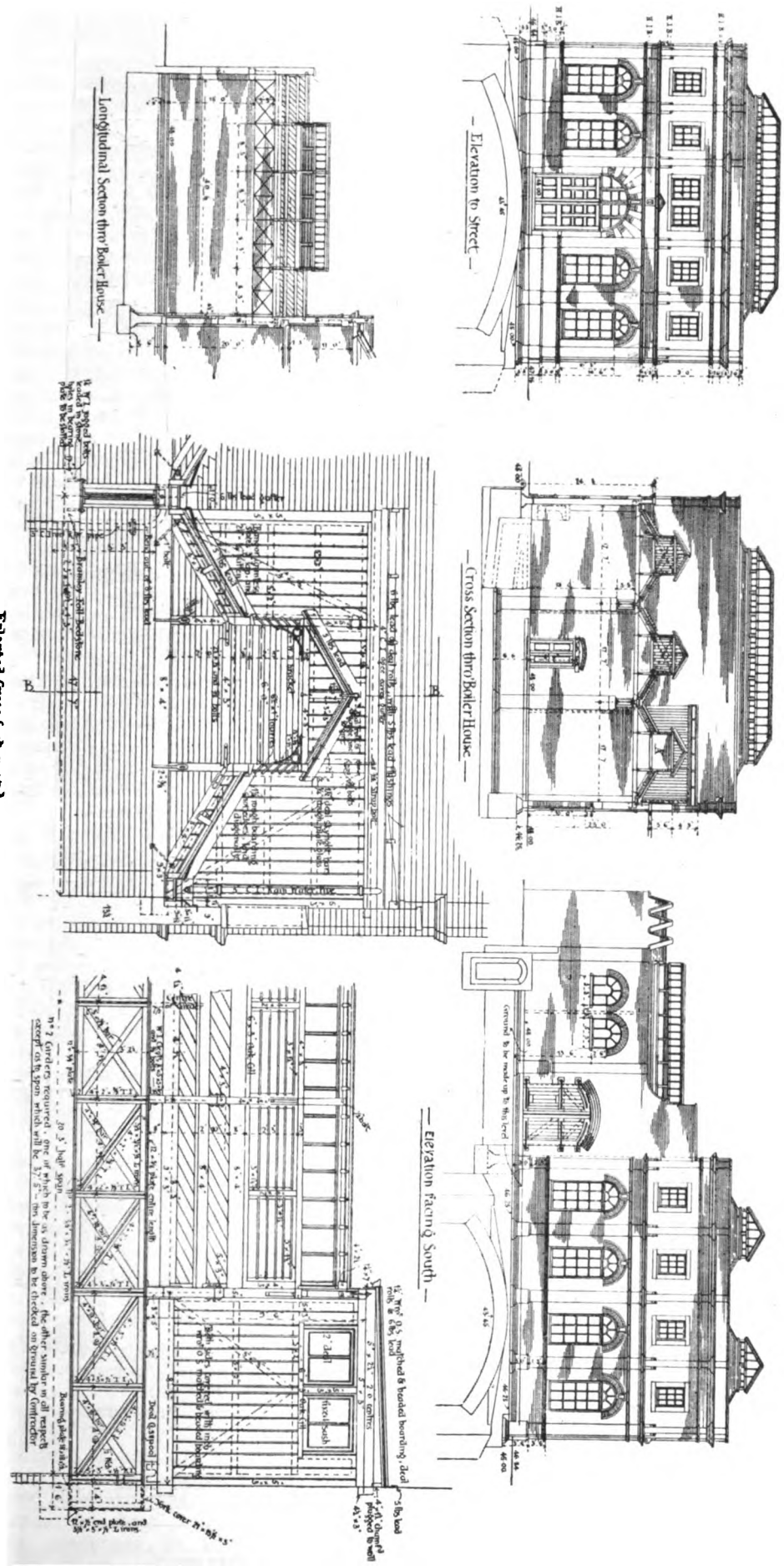
offices, in the Great Eastern Company's executive offices, the hotel close adjacent, and a number of shops and offices on the ground floor of the fine buildings with which the company has replaced the blocks of old houses formerly fronting on Bishopsgate-street.

The credit of design and elaboration of detail as regards the buildings for this supply station is largely due to Mr. J. Wilson, C.E., engineer to the Great Eastern Railway, to whose courtesy we are indebted for the illustrations that accompany this article.



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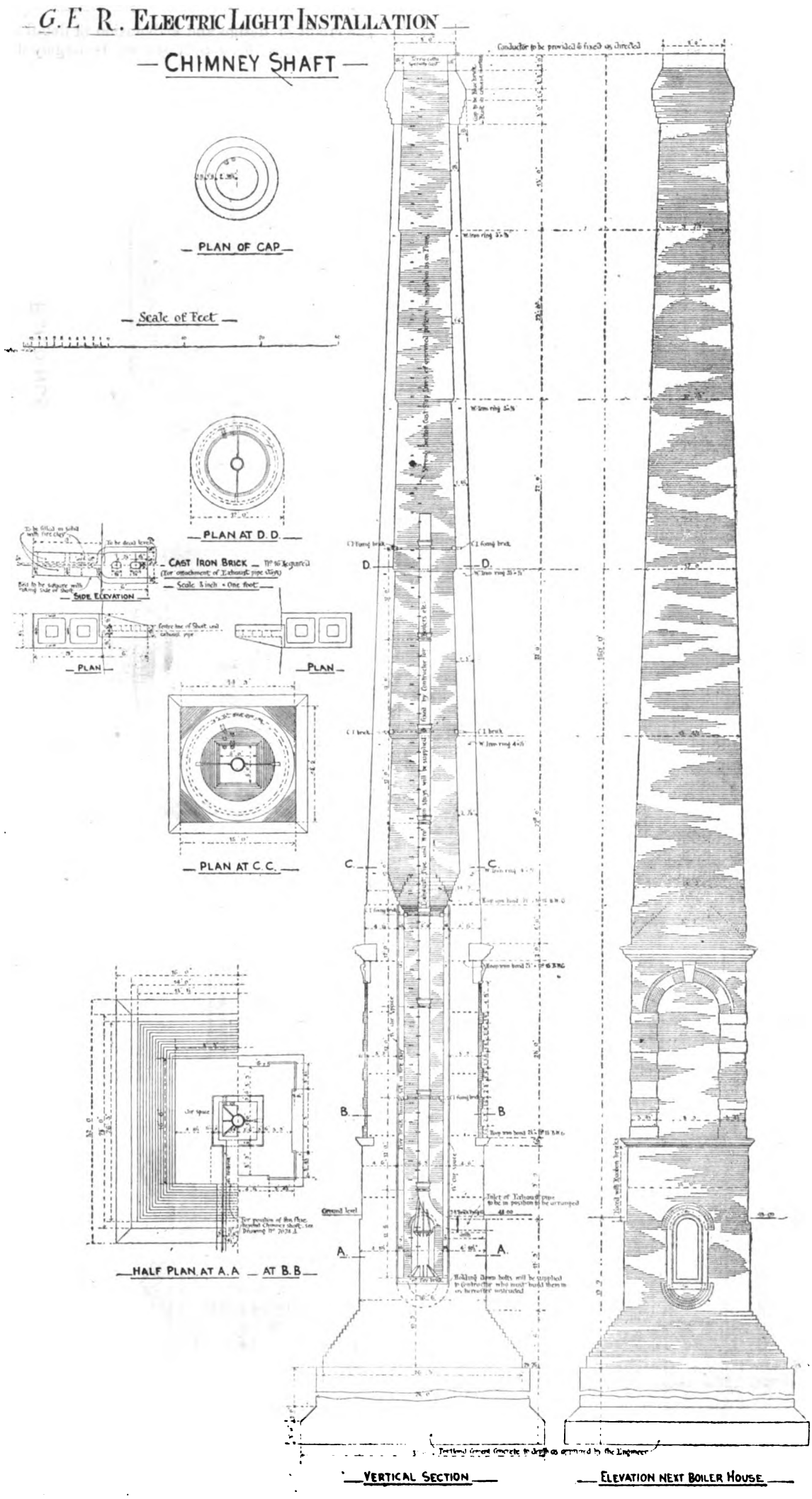

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FAULTS IN DYNAMOS.

(Continued from page 72.)

E. DISCONNECTION IN THE ARMATURE CIRCUIT.—Heavy sparking is produced on the commutator not only when the dynamo is running at its usual speed, but also when the speed is sensibly diminished, and this enables the fault to be distinguished from those previously described. As a rule, the fault occurs at some point where the wires of the armature are connected with the different segments of the commutator, and all these connections should therefore be tested, and the fault or faults repaired. If repairs cannot be effected at once, the defective segment may be joined to the next one to it, and the dynamo again started. When the disconnection is in one of the coils it should be unwound, the fault cut out, and the coil then rewound. If the dynamo is urgently required, connect the segment of the faulty coil with the next one to it. To ascertain whether disconnection exists in a coil, proceed as shown by Fig. 4.

F. SHORT-CIRCUIT IN THE ARMATURE OR COMMUTATOR. This is indicated when a brush, in passing over a bar of the commutator, gives out a spark which burns the metal. In addition, the dynamo will not give current. To see if the fault is due to metallic dust on the insulating material between the bars, each bar should be tested and cleaned. If short-circuit exists in the winding, the defective part must be found. As a rule, the short-circuited coil can be detected by its excessive heating. When the dynamo is set going to localise a short-circuit, great precautions must be taken, and the machine only run for one or two minutes at a time until the faulty coil is detected. Another method, longer, but more reliable, is to measure the resistance of each coil with a Wheatstone bridge, etc.

When short-circuit exists in a coil, the winding must be removed and the coil rewound after the fault is repaired. In case of necessity the coil can be cut out, the bars corre sponding to it connected, and dynamo restarted.

G. DEFECTIVE INSULATION OF THE FIELD COILS.—This fault is shown if the excitation is stronger in one of the field coils than in the other. One of the brushes will show more sparking than the other, and this sparking will be the same as in the case of bad adjustment. To find the fault, proceed as in "Bad Insulation of the Armature Coils."

H. WEAK MAGNETIC FIELD.—On approaching a small piece of iron to the pole-pieces, it will be seen that the magnetisation is feeble. Further, the point of least sparking will be continually altered by the disturbing action of the armature's magnetism, and the dynamo will not attain its normal voltage. The cause may be a break in the field circuit, or short-circuit in or bad insulation of the coils. If it is a break, proceed as in "Disconnection of the Field Coils." If a short-circuit in the field circuit, measure the resistance of each coil, as in "Short-circuit in the Armature Coils." Generally, the short-circuit is in one coil only, and one side of the magnetic field will therefore be weaker than the other. A small piece of iron placed exactly between them will show this by being unequally attracted.

Bad insulation of one of the coils will also create the fault. In this case one of the brushes will show more sparking than the other, and the procedure should be as in "Bad Insulation of the Armature Coils."

When the defect is accessible it is easily remedied, but when it is inside a coil the only course is to unwind, repair, and rewind.

III. ABNORMAL HEATING IN THE INTERNAL CIRCUIT.

Excessive heating of constituent parts of a dynamo may arise from various causes. In any case it is easy of recognition, because a touch of the hand from time to time will show it. So long as the temperature can be borne without pain there is no cause for alarm; otherwise—and more especially if there is smoke or a smell of burning—the dynamo should be at once stopped, and when the machine is quite cold the cause of derangement ascertained. In this way the heat will not have had time to pass by conduction to any extent beyond the defective part, which will be at the greatest heat. As a rule, no part of a working dynamo in proper order should have a temperature of more than 40deg. C. above that of the surrounding air. To take the temperature, the dynamo should be stopped and a thermometer covered with rag or cloth applied to its different parts. This does not give the dynamo time to cool, and, as the temperature of the machine-room is always known, it can be at once noted if anything is wrong. The first experiment is to localise the fault in one of the parts of the machine—armature, field magnets, or journals—while the various causes of the defect are as follows:

- A. Heating of the armature.
  - (*a*) Excessive current in the armature.
  - (*b*) Short-circuit in the winding of the armature.
  - (*c*) Foucault currents in the armature core.
  - (*d*) Humidity in the armature coils.
- B. Heating of the field-magnets.
  - (*a*) Excess of exciting current.
  - (*b*) Humidity in the field coils.
  - (*c*) Foucault currents in the pole-pieces.
- C. Heating of the journals.
  - (*a*) Defective lubrication.
  - (*b*) Metallic dust or foreign matter in the bearings.
  - (*c*) Bent, badly turned or finished shaft.
  - (*d*) Imperfect bearings.
  - (*e*) Drum or shaft making friction with the bearings.
  - (*f*) Belting too tight.
  - (*g*) Armature too near one of the pole-pieces.

A. HEATING OF THE ARMATURE.—Once abnormal heating has been found to exist, the source should be tested for:

(*a*) *Excess of Current in the Armature.*—When the fault proceeds from a surcharge from the dynamo, heavy sparking will be produced at the brushes.

(*b*) *Short-circuit in the Armature Winding.*—This fault is also characterised by heavy sparking. It should be tested for as in F.

(*c*) *Foucault Currents in the Armature Core.*—This is a fault of construction which will be perceived from the moment the dynamo is started. The engine driving it is severely taxed even before the dynamo gives current and no sparking is observable, which permits of the fault being distinguished from those previously described. A dynamo with this defect should not be taken over from the manufacturer.

(*d*) *Humidity in the Armature Coils.*—This fault or its effect is practically the same as short-circuit in the armature. To repair it the armature should be taken out and exposed to a moderate dry heat, or be subjected to a current equal to that ordinarily given by the dynamo. Under the action of heat or of this current the humidity will be gradually dispersed.

B HEATING OF THE FIELD MAGNETS.—Excessive heating of the field magnets is due to one of the three following causes:

(*a*) *Excess of Exciting Current.*—This fault is shown by an unusual heating of one or more of the field coils. When all the coils heat equally, the phenomenon is due to too strong an exciting current, and in that case extra resistance should be inserted. If, on the contrary, only one coil heats it is tolerably certain that the fault is due to a short-circuit in that coil, except the dynamo is series-wound, when it will be remembered the defective coil will heat less than that in good order. When the exciting current is too strong in a series-wound machine, it may be remedied by shunting or partly unwinding.

With a dynamo started for the first time the defect may arise from a considerable difference in the resistance of the coils, and it is a wise precaution, therefore, to test the coils for resistance before accepting the machine.

(*b*) *Humidity in the Field Coils.*—Dampness tends to decrease insulation, and the resistance of the magnetic circuit is weakened. In addition, steam is given off, and on being touched the coils will be found to be damp. When the dynamo is shunt-wound an ampere-meter will show an excess of current. In such case the coils should be dried, as indicated in "Humidity in the Armature Coils."

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(*c*) *Foucault Currents in the Pole-pieces.*—This fault may proceed from defective construction or from a variable exciting current. When the dynamo is new, therefore, the cause should be at once ascertained. Put an ampere-meter in the field circuit and note the deflection. Variations of current can only be due to imperfect contacts. If they were absolutely bad the dynamo would not give current, and the procedure should be as in "Defective Contacts."

C. HEATING OF THE JOURNALS.—When the journals are abnormally heated, and the dynamo cannot be stopped, they may be cooled with water or ice, but this must only be resorted to in case of extremity. It is far better to stop the dynamo and test for the fault, which is ordinarily due to one of the following causes.

(*a*) *Defective Lubrication.*—See that the lubricators are full and not leaking or stopped up.

(*b*) *Metallic Dust and Foreign Matter in the Bearings.*—A close and careful examination should generally suffice, but it is advisable to lift the shaft and carefully clean it, as well as the journals and bearings.

(*c*) *Bent, Badly Turned or Finished Shaft.*—A bent shaft can be easily detected by turning it, when possible, with the hand. If bent, it must be replaced. If it is badly turned or finished, the fault may be remedied by means of a lathe or file.

(*d*) *Imperfect Bearings.*—If the shaft does not turn easily, but still does not exhibit any defect when the screws (which keep the bearings in position) are removed, the bearings may be too tight and require more play, and should be readjusted.

(*e*) *Drum or Shaft Making Friction with the Bearings.*—See if there is a fair amount of play (1·5mm. to 3mm.) between the drum or the shaft and the bearings. When there is not sufficient play, the drum must be shifted or the bearings filed down a little. When the shaft is faulty, it must be made smaller in the lathe or the bearings filed down.

(*f*) *Belting too Tight.*—This fault, as before remarked, may possibly result from a surcharge from the dynamo, or it may be due to tension of the belting. In the second case, the journal nearest the drum will heat more than the other.

(*g*) *Armature too near one of the Pole-pieces.*—This is a defect of construction, and will show itself when the machine is first started. If the armature is excentric it will be unduly attracted by one of the pole-pieces, and the journals will heat as when making friction with the bearings. It is possible to centre the armature by shifting the bearings, but it is a hazardous operation. The best course is not to accept the dynamo from the maker.

(*To be continued.*)

THEORY OF THE RESISTANCE OF A STRANDED CONDUCTOR.

BY W. H. EVERETT.

The resistance of a stranded conductor is necessarily a subject that does not admit of very accurate prediction; but it may be worth while to see exactly what the resistance depends upon, and we may then, from actual data in cable lists, find rough values for those quantities which cannot be determined by calculation.

We shall first proceed to investigate the total current which passes along a layer of wires wound helically round a circular cylinder of insulating material; the wires being supposed to be so wound that each wire is in contact with the two wires on either side of it, and the helices making an angle α with the direction of the axis.

Fig. 1 is a side view of a short length of one wire, which may be supposed developed; A B is the diameter of a cross-section, and A C is drawn making an angle α with A B, so as to be parallel to the end planes of the layer of wires, these planes being perpendicular to the axis, assumed straight.

Imagine for a moment that each wire is insulated from its neighbours. Except close to the ends, the equi-potential surfaces in the wire will be planes normal to the axis of the wire; for otherwise there would be a difference of potential between A and B, which would cause a cross-current between A and B, and this cannot exist, since there is no return path.

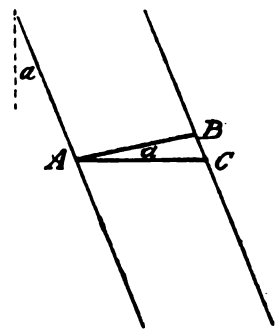

FIG. 1.

Thus the difference of potential between every pair of contiguous points in any two adjacent wirees will be

$$B C \times v,$$

where v = potential difference per unit length taken along a wire, or

$$2 a v . \tan \alpha,$$

putting $2a$ for the diameter of a wire.

Now imagine the supposed insulation to be removed from all the wires, and the above potential difference will act as an E.M.F., and send a current across from one wire to the next; in the direction A B, if the main current is flowing in the direction C B. The circuit is now completed from wire to wire in a helical path round the conductor. Suppose—

r_1 = resistance at contact between two adjacent wires per unit length;

r_2 = resistance across a wire, between its two surfaces in contact, per unit length.

Then the cross-current per unit length is

$$\frac{2 a v \tan \alpha}{r_1 + r_2}.$$

Hence the cross-current through any section, A C, of a wire, taken perpendicular to the axis of the helix, is

$$2 a \tan \alpha . \frac{2 a v \tan \alpha}{r_1 + r_2},$$

or,

$$\frac{4 a^2 v \tan^2 \alpha}{r_1 + r_2};$$

since it is the same as the current through B C. The direction of this cross-current is perpendicular to the axis of the wire.

The main current along a wire—that is, the current parallel to the axis of the wire—is

$$\frac{\pi a^2 v}{\rho},$$

ρ being the specific resistance of the metal.

The total current along any wire—that is, the total current across a section of it perpendicular to the axis of the helix—is therefore

$$v a^2 \left\{ \frac{\pi}{\rho} + \frac{4 \tan^2 \alpha}{r_1 + r_2} \right\}.$$

And if there are n wires in the conductor the total current through a normal section, and therefore through any other complete section of it, is

$$n v a^2 \left\{ \frac{\pi}{\rho} + \frac{4 \tan^2 \alpha}{r_1 + r_2} \right\}.$$

This result can be stated thus: Find the current that would exist if all the wires were insulated from one another, and increase this in the ratio

$$\left(1 + \frac{4}{\pi} . \frac{\rho}{r_1 + r_2} \tan^2 \alpha \right) \text{ to } 1$$

to find the whole current. Or we may say that the resistance is decreased in this ratio.

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The equipotential surfaces in the layer will, in section, be a series of curves having points of inflection where they cross the axis of the wire, and also where they pass from one wire to another. They will be nearly straight in the neighbourhood of the axis of each wire, and will there be least inclined to a section normal to the axis of the wire. They will reach their greatest curvature near the contact surface between any two wires, and will have their maximum inclination in passing through the contact surface.

The precise shape of the curves depends, of course, on the nature of the contacts and the distortion in the adjoining parts of the wires. However, their form is shown sufficiently in Fig. 2, and will be seen to resemble that of waves in shallow water.

The effect of the cross-current on the resultant current is greatest at the parts in contact, the cross-current attaining there its maximum density.

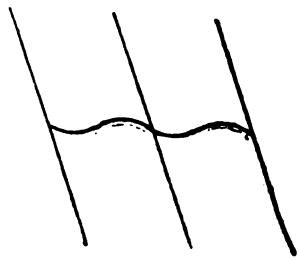

FIG. 2

We may now proceed from the consideration of a single layer to the case of a conductor formed of two or more such layers, the helices in any two contiguous layers being wound in opposite directions; in fact, the case of an ordinary cable.

If the region of contact between every two wires in contiguous layers were so small that it might be regarded as a mere point, then no current would pass between one layer and the next, since there would be equality of potential at every such point of contact.

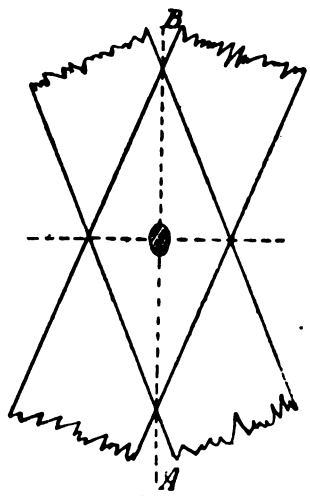

FIG. 3.

If the region of contact is not of negligible size, we may reasonably assume it to be symmetrically placed with regard to the two wires, so as to be divided equally by the bisectors of the angles between these two wires. By drawing equipotential lines for each wire, we see at once that there will be no difference of potential between the two wires at points on the longitudinal bisector, A B (Fig. 3); and on opposite sides of this line the differences, at corresponding points, will be equal and of opposite signs.

Hence there will be a resultant couple of potential differences, causing an eddy current round the longitudinal bisector; but there will be no resulting current from one wire to the other.

Therefore contact between contiguous layers does not increase the conductivity of a stranded conductor, but would tend, on the contrary, to decrease the conductivity. For the eddy currents would cause a waste of energy, E.M.F. being absorbed. This effect is probably almost, if not quite, negligible, owing to the small area of the contact surfaces. But it is noteworthy that the conductivity of a cable will, if anything, be increased by inserting a film of insulation between successive layers.

We may say, then, that each layer is independent of the others, and simply carries a current proportional to its conductivity as found above.

Accordingly, a stranded conductor acts really as a number of conductors in parallel—namely, the different layers. The current density and heating effect may therefore vary slightly in the different layers, depending in any layer on its helical slope and its resistance to cross-current.

We may subsequently examine a little more closely the expression found for the conductivity of any layer, and compare it with the results obtained in the case of actual cables.

(To be continued.)

ELECTRIC RAILWAY MOTORS: THEIR CONSTRUCTION AND OPERATION.*

BY NELSON W. PERRY.

(Concluded from page 86.)

I have often heard it claimed by horsemen, and have seen several instances myself where good results seemed to follow the plan, that to start a balky horse the best way is to simply jump out of the wagon and pretend to fix the horse's bridle, then get in, and on giving the signal, the horse which neither whips nor oaths could budge before would start right off as though nothing had happened. This was exactly what my friend seemed to have done and nothing more, and when, after we had all followed the injunction to get "aboard," he commenced to turn on the current, I could not but be astonished at the cheek, or, rather, the assurance which enabled him to keep up the appearance of entire confidence in the success of another attempt which he knew must fail for exactly the same reasons the other had. It is needless to state what the result was, further than to say that we did not get quite as far this time as we had before, and it is also needless for me to state how with equal composure he gave some excuse for going back again to the starting point. I think he said he had forgotten his monkey-wrench or something else.

I determined this time to speak, and when we stopped at the bottom I got off and commenced looking around as if hunting for something, and, stooping down some distance from the car so as to get him alone, cried out, "I've found it," and, as I expected, he rushed over, leaving the others behind, and I whispered, "Look at your positive brush on the front motor." He heard me and understood. He stooped down, though, as if to examine what I pretended to have found, and then, in tones loud enough to be heard by the others, said, "No, that's not it, but I've got something that will do as well," and lost no time in getting under the car and repairing the broken connection which had rendered useless one of our motors.

When we got on to the car again and he grasped the controlling switch I know I had more confidence that we could ascend the grade, but his appearance betrayed not one whit more than it had on the two previous attempts. As for the other parties, I am sure there was never a suspicion. We completed the return trip in great shape, and the trial trip was pronounced a success, and my friend was the hero of the hour. We returned to the car barns, and after he had seen everything safe for the night we walked home together. He seemed buried in deep thought for some distance, but finally broke the silence by, "You played me a darned mean trick." I was very much surprised at his attitude, thinking that he should rather have thanked me for helping him out of his difficulty. I knew that he would have found the difficulty after a while if left to his own resources, but thought I had saved him some embarrassment which further delay might have caused him, so I laughingly asked "How?" to which he replied, "By not letting me know before that you were an electrician."

The above anecdote is related merely to show how a little bravado judiciously used may save a reputation where

* From the *Street Railway Gazette*.

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entire candour would be fatal. However reprehensible this practice may be in the abstract, it is one that pervades all walks in life, and is nowhere more prevalent, perhaps, than in the medical profession. It is, in fact, often used there to advantage, for if the physician should fail to inspire his patient with confidence in the beginning, it would be almost impossible for him to succeed later, and it is conceded that confidence in one's physician as well as in the remedies one takes is of the greatest help in curing disease.

If we find this practice so general in such an honourable profession as medicine, it is not surprising if we find it in the motorman, nor can we disparage it there while we uphold it elsewhere. In fact, I believe the motorman or electrical artisan is really less to blame than many others, by the circumstances of his position. Most often the electric motorman has obtained his position as a reward for faithful services as a driver or conductor of a horse car. In his previous occupation his hours have been long and his work exhausting both to mind and body, and when his day's work is done he is in no condition for study or more work. Besides, as a driver, he has probably mastered his business, and there has been no incentive to further study.

With this habit of mind he is transferred without any special preparation to the responsibilities of the care of the electrical equipment of his car. He is broken in by some one who has had a little more experience than he has had, and after having been shown the various parts of his apparatus and how they are intended to operate, is given a set of rules which tell him that he must do this and must not do that, and is allowed then to shift for himself. He is expected to talk about a current which he can't see and to guard against results which he knows only by name. A new language is placed in his mouth which he does not understand, but which he understands somehow is intimately connected with his business. His hours are no shorter than before, and books which would explain matters are too expensive, even if he had time to read them, or entirely inaccessible. His companion motormen are using this new language familiarly, and he soon acquires that habit almost unconsciously, and as soon as he is thus initiated into the charmed circle which speaks this foreign language, he becomes with his brother motormen a class distinct from that class from which they have all sprung. If he knows little of electricity, he still knows more than his former companions, and they treat him with a respect due to his superior knowledge. It will not do for him to admit ignorance, and he has an answer ready for every question. Nor does he care to show his ignorance among his companions by asking them questions or by asking questions of others in their presence, and in this way too often stands in his own light. That the average motorman is anxious to inform himself where he can do so under circumstances which are not embarrassing, I know well from personal experience, for I have had individuals ply me with questions when they could get me alone who would rather have died almost than to have asked the same questions in the presence of fellow-workmen.

No one blames them for this. It is human nature, and, as I have stated before, they have shining examples in the same practice in members of professions considered more dignified than theirs.

It was in the firm belief that the motorman would gladly inform himself, and therefore improve his position, if the opportunity were but offered, that the editors of the *Street Railway Gazette* have asked the writer to contribute a series of articles on electrical subjects which should gradually lead up to the street car motor and its management.

I feel sure that if the readers of the *Street Railway Gazette* will follow these articles conscientiously from week to week, they will be able to gain an intelligent knowledge of the theory of the electric motor which will often stand them in good stead and enable them to master situations not usually provided for in the rules and instructions with which they are furnished. With this added knowledge they will not only be more self-respecting, but be more respected, and as their usefulness is increased to their employer, so will their services to him become the more indispensable and preferment be more certain.

THE SCIENTIFIC USES OF LIQUID AIR.

A large and distinguished audience assembled at the Royal Institution on Friday evening to hear Prof. Dewar's lecture on "The Scientific Uses of Liquid Air."

To the majority of people, liquid air is only a scientific marvel; to a few it presents a collection of unsolved and most interesting problems, while at the Royal Institution it has become a valuable instrument of physical research. Produced in large quantities and stored by novel and ingenious methods, it is employed in the study of matter at 200deg. below zero, exactly as a spirit-lamp or a gas flame is used in studying the properties of different bodies at temperatures equally removed in the opposite direction from the normal. Prof. Dewar's lecture dealt in part with some properties of the liquid itself which have not previously been studied in equally favourable conditions, but was more particularly concerned with indicating the various important applications of a new and potent instrument of physical investigation.

Liquid air was shown in a condition which, though probably offering nothing novel to the eye of the untrained observer, is yet essentially different from anything hitherto shown on a lecture table. It has always been seen either in a state of active ebullition at ordinary pressure or of steady evaporation at the lower temperature produced by the action of an air-pump. On Friday night it was shown as a permanent fluid giving off no gas. Or, to put the matter another way, it has hitherto been shown imperfectly screened from the heat of surrounding bodies, while now it has been placed in such conditions that no extraneous heat could reach it. Formerly its temperature was kept down by its own evaporation, exactly as the temperature of boiling water is kept constant over the hottest fire. As exhibited by the lecturer its temperature was kept constant without loss of mass. This is effected by placing the liquid in a vacuum jacket, which is immersed in liquid oxygen contained in a second vacuum jacket and connected to an air-pump. Convection is annihilated by a vacuum which must be all but absolute, and conduction is shut out by the surrounding oxygen. No access of heat is possible except by radiation pure and simple, and this has already been proved to be, if not non-existent, at all events infinitesimally small. It is an interesting incident of the arrangement that common air can be shown in the solid condition. The importance of the complete isolation of the liquid lies in the fact that exact experiments can be made for the determination of its specific and latent heat. By lowering into the liquid a definite mass of platinum and measuring the gas evolved, it is easy to calculate the heat that becomes latent in converting the liquid into gas. Using similar methods to heat the liquid to a definite extent without altering its condition—*i.e.*, without converting it into gas—the specific heat can be calculated from the variation of pressure as registered by a column of mercury.

Taking a very highly exhausted bulb, containing only a little vapour of mercury at a pressure of a millionth of an atmosphere, and cooling it with liquid air until that minute portion of metal was frozen solid, the lecturer illustrated the part played in electrical discharges by ponderable matter. In a high vacuum at 200deg. below zero the difficulty of passing an electric spark in any form becomes almost insuperable. It would not be an extravagant inference from the phenomena were we to affirm that at 274deg below zero, when the rarest gas known to us would have suffered condensation, electrical discharge through the frozen void would become altogether impossible. But there are constant warnings in physical science of the danger of pushing inference beyond experiment, at all events in regions where we are approaching the extreme limit of our resources. By enormously increasing its voltage, the current may be made to pass even through the frozen-out mercury vacuum. But the discharge assumes a totally different form, the diffused phosphorescence giving place to luminous streaks. It would seem, therefore, that after a certain degree of rarefaction has been attained the gaseous molecules are no longer sufficient in number to act as carriers for an ordinary charge, while a more powerful one bridges the space only by the aid of the few that remain. The result almost justifies the presumption that ponderable matter is always necessary for the passage of electricity through space, but at the same time it opens up the question whether space can ever be wholly free of ponderable matter. If a certain amount of vapour be still given off by mercury at 140deg. below its freezing point, to what temperature below minus 274deg. must we suppose hydrogen to be cooled in order to ensure that no residuum shall remain in the gaseous form?

Prof. Dewar carried out a very simple but very striking experiment which forcibly demonstrates the truth of the molecular theory. He took a high-vacuum bulb containing only a minute quantity of mercurial vapour, to which was connected, by a short neck of from $\frac{1}{10}$in. to $\frac{1}{8}$in. bore, a smaller bulb containing liquid mercury. On applying liquid air to a portion of the larger bulb the contained vapour was at once condensed as a small mirror. On applying the liquid to a second portion of the glass no further condensation was obtained, thus proving that the metallic surface a couple of inches below could not supply vapour to replenish the larger bulb. But on inclining the apparatus so as to pass a globule of mercury into the larger bulb itself, the cold spots on the glass were instantaneously covered with dense metallic deposits. Of the myriads of molecules projected in all directions from the liquid mercury in the smaller bulb only a small percentage—which might be determined by the theory of probabilities—struck the orifice of the neck in such a way as to shoot clean through into the larger bulb. Hence the loss from condensation could not be made good, although there was free communication with another chamber containing vapour at a relatively high pressure.

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The lecturer showed the method of determining the tensile strength of metals at 180deg. below zero. Large quantities of liquid air are necessary, since the considerable mass of metal forming the jaws of the testing machine has to be completely immersed. The results are extremely interesting. The breaking strain is in all cases greatly increased, and in some—*e.g.*, iron and German silver—is nearly doubled. In the case of certain metals equally remarkable increase occurs in the percentage of elongation before rupture, though the results on this point require verification. Thus, while chemical forces are in abeyance at very low temperatures, the physical force—which we call cohesion—asserts itself with immensely increased power. This is of great importance in connection with theories which have been ably advocated in some quarters, according to which a sufficient reduction of temperature would reduce the universe to "cosmic dust." That material, so valuable to some speculators, will have in future to be obtained from some other source than the disintegration of matter by cold. Lord Kelvin maintains, on the other hand, that cohesion may be accounted for without assuming any other force than that of gravitation, or any other law than the Newtonian. Contraction of bulk without reduction of mass is the sole condition he requires for indefinite increase of cohesive force, and this is obviously the condition supplied by Prof. Dewar's experiment, while the result is entirely concordant with Lord Kelvin's theory.

An American experimenter has found that a temperature of 80deg. below zero very greatly diminishes the power of a permanent magnet. Prof. Dewar has proved that this result follows only in the case of a super-saturated magnet. If a magnet be taken which has been passed through ordinary cycles of change, and therefore carries what may be called a normal charge of magnetism, its magnetic activity is markedly increased by reduction of temperature. This was shown by direct experiment, and the result was confirmed by coiling a wire round the magnet at ordinary temperature and immersing the end of the magnet in liquid air, when an electric current was instantly generated in the wire. An immense field of work lies before the physicist in connection with these experiments alike upon cohesion and upon magnetism. There are various theories which will have to take account as best they can of facts which cannot be questioned, however they may ultimately be explained. The increase of cohesion and magnetic force at very low temperatures must be taken in conjunction with the disappearance of electrical resistance in pure metals already worked out at the Royal Institution, and this, again, is complicated by the reverse effect obtained when the metals are contaminated by impurities of any kind.

Low temperature was shown to have a remarkable effect upon the colour of many bodies. For example, the brilliant scarlet of vermilion and mercuric iodide is reduced under the influence of intense cold to a pale orange, the original colour returning with the rise of the temperature. Blues, on the other hand, are unaffected by cold, and the effect is comparatively small upon organic colouring matters of all tints. This is of interest in connection with the efforts that have been made to find a chemical explanation of the colour of salts, and, indeed, with the phenomena of isormorphism in general.

COMPANIES' MEETINGS.

NATIONAL TELEPHONE COMPANY.

An extraordinary general meeting of this Company was held last week at the Cannon-street Hotel.

Mr. J. S. Forbes, who presided, stated that the directors felt that it would be to the interest of the Company if there were more frequent opportunities of meeting the shareholders. The Government had come to the conclusion that the intercommunication between the great centres for telephonic purposes must be taken over by them, and the Company and other licensees were to be charged with a limited service in certain areas. The State was to provide the communication in the nature of trunk wires in all the great centres, and the Company were to co-operate with the Post Office in carrying on with efficiency, and as economically as circumstances justified, telephonic communication, both local and through. This matter had now been pending a long time. There had been a change of Government since the Company entered into their agreement with the Post Office, and the agreement was in a state of suspense. Meanwhile, one of its conditions had been somewhat altered. When the Postmaster-General, duly authorised by the Government, put his initials to the heads of the agreement the directors assumed that that was the agreement; but there had been some discussion in Parliament on the subject, and the Government had pledged themselves not to complete the arrangement until it had been submitted to Parliament. During the last two months Parliament had been occupied upon matters even more vital to the community than the efficiency of the telephonic communication, and the result was that the agreement was not yet through. Their business was thus obstructed, and the general convenience was being neglected. The Company's year ended on April 30, but this was found to be very inconvenient, and they proposed that they should follow the custom of most of the great commercial companies, making up their accounts to June 30 and December 31—the two meetings which they suggested should be held in the year being arranged to fit in with those dates. Although they could not take any resolution on that occasion binding on the Company, they would like to have an expression of opinion which would justify them in taking such measures as would be legally requisite for making these changes. The accounts had been prepared for the half-year ended October 31, and they would be issued to the shareholders with the report of that day's proceedings. Complaints were still made against them, and he recently read that unless they went to Stockholm it was impossible to arrive at any clear comprehension as to how bad they were. His answer, however, was that Stockholm was not London. If they could get rid of the cost of wayleaves and of the Post Office royalty amounting to about 25 per cent. of the net income of the Company, and if they could also get rid of the awful difference which there was between 3s. 6d. a day for skilled labour in Germany as well as in many other parts of Europe, and 6s. or 7s. a day in England, they would be able to do their business cheaper. When they were accused in the *Times* with being the dearest and the worst thing of the kind in the world, he confessed that he was put out a little, and "the saddle ought to be put on the right horse." There was a delusion that their subscription in London was £20, but that was not the case. They had over 10,000 subscribers in London, and £15 was the average payment. He concluded by moving a resolution to the effect that two ordinary general meetings should be held in each year, and requesting the directors to take the necessary steps to have the articles of association of the Company altered accordingly.

Lord Balfour of Burleigh seconded the motion.

The **Chairman**, in answer to questions, said there was no doubt they must have a large reserve fund, but the time had not yet arrived when it need be determined whether the fund should be invested in securities apart from the business. At the present time it was in the business. The amount was £161,400. Their tenure was 18 years from the 1st inst., but the Government could resume possession before the end of that period. If the Government, under their powers, gave them notice in 1897, they would take possession on arbitration terms, but he did not believe that less than justice would be done by them in such a case. If their agreement with the Post Office were dealt with by the House of Commons in a manner detrimental to the Company, the latter would reserve their rights of re-entry.

The motion was adopted.

DIRECT UNITED STATES CABLE COMPANY.

The thirty-third ordinary general meeting of this Company was held at Winchester House on Tuesday, Sir John Pender, M.P., presiding.

In moving the adoption of the report, the **Chairman** pointed out that the revenue for the half-year ended December 31 last amounted to £41,051, as compared with £43,629 for the corresponding period of 1892, being a difference of £2,577 against the half-year under review, which was due to the severe commercial depression and the interruption in cable communication. The working and other expenses for the same period, including income tax, had amounted to £19,059, leaving a balance of £21,992 as the net profit, making, with the balance of £819 brought forward from the previous half-year, a total of £22,811. For the corresponding period of 1892 the working expenses and other payments amounted to £18,982. They had been able to pay interim dividends of 3s. 6d. per share for the quarter ended September 30, and of 3s. per share for the quarter ended December 31. These dividends amounted to £19,730, and they carried forward £3,080 on the revenue account. Although they had carried more traffic than in 1892, their receipts has been less. He hoped for better things in the future, though he expected that it would take some time before they returned to the old prosperous period. He thought, however, that he saw some sunshine. Complaint had been made of the reduction of the dividend from 3½ per cent. to 3 per cent.; but, considering that they had paid 5 per cent. for a long time, that they had a reserve fund of £101,000, and that they had paid off £21,000 in respect of cables and £100,000 in debentures, he thought the action of the directors was rather to be applauded than condemned.

Mr. E. M. Underdown, Q.C., seconded the resolution, which, after some discussion, was adopted.

COMPANIES' REPORTS.

CITY AND SOUTH LONDON RAILWAY COMPANY.

Directors: Charles Grey Mott, Esq., Harrow Weald Lodge, Stanmore, chairman; Charles Seymour Grenfell, Esq., Elibank, Taplow; Sampson Hanbury, Esq., Wyvenhoe Park, near Colchester; S. Barclay Heward, Esq., 96, Ashley-gardens, Westminster; Edwin Tate, Esq., 21, Mincing-lane, London, E.C.

Report of the directors for the half-year ending December 31, 1893, to be submitted to the half-yearly ordinary general meeting of the Company, to be held at Winchester House, Old Broad-street, E.C., on Thursday, February 1, 1894, at 12 o'clock noon.

The receipts from all sources for the past half-year have amounted to £22,821. 7s. 9d., and the cost of working has been £14,761. 11s. 3d., leaving a profit of £8,059. 16s. 6d. Inclusive of the balance brought forward from June 30 last, the net revenue account shows an aggregate total of £8,927. 10s. 7d. After making provision for the debenture and debenture stock interest, a balance remains available for dividend of £4,792. 8s. 10d. Out of this sum your directors recommend the full dividend of 5 per cent. per annum be paid on the preference shares, and that a dividend at the rate of ⅝ per cent. per annum be paid upon the consolidated ordinary stock, leaving a balance of £1,063. 13s. 10d. to be carried

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forward to the next account. The following table shows the number of passengers, exclusive of season-ticket holders, carried since the opening of the railway in each half-year :

Half-year ended	Number of passengers.	Receipts (including season tickets. £ s. d.
December 31, 1890 (11 days)	165,000 ..	1,568 3 9
June 30, 1891.....	2,412,343 ...	19,403 6 9
December 31, 1891	2 749,055 ...	19,798 16 6
June 30, 1892	2,813,162 ...	20,931 4 2
December 31, 1892	3,117,602 ...	22,002 17 5
June 30, 1893.....	3,146,656 ...	22,458 6 9
December 31, 1893	3,093,351 ..	22,067 14 10
Total since the opening of the line	17,497,169 ...	£128,230 10 2

The traffic for the past half-year was prejudicially affected by the long continuance of exceptionally fine weather, and by the closing of Kennington Oval for the purpose of relaying the turf, so that no football matches have been played there this season. These causes, added to the general depression of trade, have caused a slight diminution in the number of passengers carried ; but, notwithstanding this, the general revenue receipts show a small increase over the corresponding period of last year, and the cost of working has been further reduced in spite of a considerable addition which has again been made to the local rates. The locomotives, rolling-stock, generating and other plant have been adequately maintained, and are in efficient working condition. The additional rolling-stock referred to in the last report is in course of delivery. The new sidings at the Stockwell Station are now in use, and prove a great convenience in working the traffic. The alterations at the King William-street Station are nearly completed. These will greatly enhance the comfort and convenience of passengers, and at the same time provide a ladies' waiting-room, and a room for left luggage and parcels, which will be a source of revenue to the Company. In the course of the half-year, £32,200 of the terminable 5 per cent. mortgage debenture bonds have been paid off, and are being reissued as 4 per cent. perpetual debenture stock. The Bill promoted by this Company for the extension to Islington and other purposes received the Royal assent on August 24 last. The parliamentary expenses incurred in connection with this Act were largely increased by it having been carried over from one session to another owing to the dissolution of Parliament, but having paid dividends in the meantime on the ordinary stock, the Company is now relieved from the obligation to provide the parliamentary deposit, whereby a very considerable saving will be effected. The directors retiring by rotation are Messrs. Sampson Hanbury and Spencer Barclay Heward, who are eligible for re-election. Mr. James Loriner Oliver is the retiring auditor, and is eligible for re-election.

REVENUE ACCOUNT, HALF-YEAR ENDING DEC. 31, 1893.

Dr.	£ s. d.
Maintenance of way, works, and stations	563 8 0
Locomotive and generating power.....	5,814 13 1
Carriage repairs	430 4 3
Traffic expenses	5,757 2 7
General expenses.....	1,646 3 9
Law charges	33 10 5
Compensation	—
Rates and taxes	511 6 9
Passenger duty.....	5 1 8
	14,761 11 3
Balance carried to net revenue account	8,059 16 6
	£22,821 7 9

Cr.	£ s. d.
Passengers (3,093,351)	21,368 16 1
Season tickets (348)	698 18 9
	22,067 14 10
Parcels, etc.	25 4 6
Transfer fees	6 2 6
Rent of property.....	600 18 1
Sundry receipts	121 7 10
	£22,821 7 9

Dr. GENERAL BALANCE-SHEET.	£ s. d.
Balance from net revenue account.....	4,792 8 10
Unclaimed interest.....	72 9 0
Interest payable or accruing and provided for	1,239 4 0
Sundry outstanding accounts	7,193 15 3
Construction reserve	2,030 8 11
Loan account	22,000 0 0
	£37,328 6 0

Cr.	£ s. d.
Cash at bankers, current account	1,650 6 3
Cash on deposit at interest	2,000 0 0
Cash in hand	393 4 11
	4,048 11 2
General stores	3,168 14 8
Sundry outstanding accounts	460 14 9
Balance from capital account.....	29,650 5 5
	£37,328 6 0

BUSINESS NOTES.

Margam.—Messrs. Drake and Gorham are to report on the electric lighting of this district.

Dublin.—The Town Council have received sanction to a loan of £24,400 for extending the electric light system.

Dover.—The Town Council have received from Mr. J. Matthews plans for the electric light station to be built at Ladywell.

Buxton.—The chairman of the Local Board has announced that a meeting regarding the Electric Lighting Acts would be held in month's time.

Debenture Issue.—The Chatham, Rochester, and District Electric Lighting Company is inviting subscriptions for its 5 per cent. first mortgage debentures.

Belfast.—The Electrical Committee of the Corporation have had under consideration Prof. Kennedy's report regarding the tenders received for electric lighting plant.

St. Pancras.—The Vestry have decided to lay an electric main from Tottenham Court-road along Grafton-street, and along each side of Fitzroy-square, at a cost of £495.

Electric Lighting in Aberdeen.—The electric light current will be passed through the mains in this city on February 19. The Lighting Committee have agreed to erect six additional lamps.

Woking.—The clerk to the Local Board mentioned at a meeting last week that no further tenders had been received for lighting. It was therefore decided to accept the tender of the electric lighting company.

Bradford.—The new Yorkshire Penny Bank has been equipped with an electric light installation by Mr. T. Harding Churton, of Leeds, and with electric bells and lightning conductor by Messrs. James Davis and Co., of Bradford.

Edinburgh.—The Lord Provost's Committee of Edinburgh Town Council have accepted an estimate for the removal of certain buildings at Dewar-place on the site of the proposed central electric lighting station at Torphichen-street.

Birmingham.—Twenty-three firms of architects have been invited by the Markets and Fairs Committee of the Town Council to send in competitive sketch plans for the new meat market and slaughter-houses, which are to be provided with an electric light installation.

Tender Accepted.—The tender of Messrs. Maxwell Bros. has been accepted for new mahogany fittings and electric lighting at St. Paul's Wharf, Upper Thames-street, E.C., for Messrs. Lever Bros. The amount for fittings was £103, and for electric lighting £75.

Llandrided Wells.—At the last meeting of the Local Board the clerk read a lengthy correspondence on the subject of electric lighting. It appeared that one company was willing to establish a temporary plant next season as an experiment. The question was again adjourned.

Tenders Required in Edinburgh.—Tenders are invited for an electric light installation in Chancelot Roller Flour Mills, Edinburgh. Specifications of the work required can be had by applying to the Secretary, Scottish Co-operative Wholesale Society, Limited, 119, Paisley-road, Glasgow.

Elmore's Foreign and Colonial Patent Copper Depositing Company, Limited.—Two petitions (one by Mr. J. Stevens, the other by Sir J. R. Meades) were down for hearing on Wednesday. It was stated, however, that the matters had been arranged, and the petitions were dismissed.

The Lighting Question at Chester.—An "open letter" to Dr. Hopkinson, consulting electrical engineer to the Corporation of Chester, has been sent by Mr. J. H. Wynne to a local paper. The writer criticised the proposal to combine electric light works and baths, and suggests that a new site should be obtained.

City and South London Railway.—The receipts of the Company for the week ending January 21 were £947, against £973 for the same period last year, or a decrease of £26. The total receipts for the first half-year of 1894 show a decrease of £91 compared with those for the corresponding period of 1893.

King's Norton.—The medical officer to the Rural Sanitary Authority, Dr. Hollingshead, has informed the Authority that the hospital was badly lighted, and he suggested that electricity should be substituted for the present system of oil illumination. It was resolved to defer the consideration of this question.

Portsmouth.—A Vestry meeting was held last week at St. Jude's Church, Southsea, to take into consideration the subject of laying on the electric light to supplant gas. An estimate furnished by electricians was that the cost of the alteration would be £300, but after a discussion the parishioners resolved to defer the matter.

Messrs. Drake and Gorham.—We understand that as the result of the lighting at Chatsworth, which has just been completed by Mr. Drake, he has been entrusted with the entire remodelling of the installation at 45, Belgrave-square by the Duchess of Montrose, who has lately been staying at Chatsworth. Over 300 lights are being arranged for.

Liverpool Overhead Railway.—The traffic receipts of this railway for the week ending 21st inst. amounted to £656. The directors have resolved to recommend payments of dividends at the rate of 5 per cent. per annum on the preference shares, and 1 per cent. per annum on the ordinary shares of this Company, less income tax, carrying forward £2,598.

Tenders Wanted for Leeds.—Tenders are now being obtained by the Yorkshire House-to-House Electricity Company, Limited, of Leeds, for an extension of the works. Two additional engines of

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400 i.h.p. each are to be put down, together with corresponding electrical plant. Mr. R. Hammond is the consulting engineer, and the architects are Messrs. Milnes and France, of Bradford.

Tenders for Halifax.—Tenders are required by 1st February for the mason, joiner, ironfounder, slater, plumber, painter, and concrete work required for the erection of the electric lighting works in Foundry-street, Halifax, for the Electric Lighting Committee of the Halifax Corporation. Plans and specifications may be seen and forms of tender obtained on application to Mr. W. H. D. Horsfall, architect, 9, Harrison-road, Halifax.

Tenders Wanted for Blyth (Northumberland).—Tenders are invited by the 7th proximo for the lighting of the district for a term of 10 years, for the Cowpen District Local Board (Blyth, Northumberland). Plans of the district may be seen at the office of the Board, Commercial-buildings, Waterloo, Blyth, and particulars can be obtained from the Board's surveyor. Tenders to be sent to the clerk, Mr. Robt. T. Guthrie, Blyth.

Ayrton and Mather's Electrostatic Voltmeter.—Mr. Paul, of Hatton-garden, E.C., informs us that he supplied these instruments to the following electric lighting companies during the past year: The Metropolitan Electric Supply Company the City of London Electric Lighting Company, the London Electric Supply Corporation, the Brush Company, the Laing, Wharton, and Down Syndicate, besides the Bristol and Derby Corporations, and several foreign firms Mr. Paul has in hand some new patterns for lower readings.

Appointment of Receiver.—In the Chancery Division of the High Court of Justice last Friday, before Mr. Justice Chitty, Mr. Clapham, a holder of debentures in Latimer Clark, Muirhead, and Co., Limited, asked for a receiver and manager of the business and property of the company charged by the debentures. Mr. Kenyon Parker made the application, and Mr. C. E. E. Jenkins represented the defendants. Mr. Justice Chitty made the order asked for, appointing Mr. James Worley, with liberty to borrow up to £4,000 for the purpose of carrying on the business.

Cullingworth.—Since the Cullingworth Mills came into the possession of Messrs. J. J. Broadbent and Co, Limited, extensive additions and alterations have been made which have necessitated the provision of additional motive power, and Messrs. Marsden and Co., of Union Foundry, Heckmondwike, have recently completed the erection at Cullingworth of a pair of engines of modern type. Tate's electrical stop-motion has been applied, so that the engines may be stopped immediately from any part of the building in case of accident. The engine-house will shortly be fitted with electric light.

Issue of Debentures.—Messrs. Sperling and Co. have this week offered for subscription £100,000 5 per cent. debentures of £40 each of the Victoria Electric Railway and Lighting Company, Limited, at the rate of £98. 15s. per cent. These debentures are redeemable by 1932, by the application of a 1 per cent. sinking fund and annual drawings, for the first 10 years at £105 per cent, and thereafter at £100 per cent., and from a first mortage absolute on all the property, rights, etc., of the undertaking. The company has for 50 years the sole right to organise and work tramways, electric cars, etc., in the city of Victoria, British Columbia.

Bournemouth Electric Lighting License.—The Corporation of Bournemouth have applied to the Board of Trade for an electric lighting license for the purposes of lighting the pier, pleasure grounds, winter gardens, and other properties belonging to and under the control of the Corporation, a scheme for which has been prepared by Mr. F. W. Lacey, the borough engineer. The local electric supply company have written to the Board of Trade to the effect that they do not desire to oppose the application. The London and South-Western Railway Company have also withdrawn their opposition. The work therefore will now probably be carried out an early date.

Larne.—The clerk to the Town Council has read at a meeting of the latter an extract from a letter from Mr. Norris, the manager and liquidator of the electric light company, in which he stated that if the Commissioners press the matter of security, he thought that possibly some way could be found to meet the difficulty. The Commissioners might retain part of the payment until completion of the contract. It was decided that the clerk should write to Mr. Norris, asking if he would be agreeable to allow the £100 due by the Commissioners on April 1 next to lie in their hands as security for the performance of the contract for the lighting of the town for the ensuing three years.

Tenders Required for Yarmouth.—The Corporation invite tenders for the construction, supply, and laying down of the plant and mains for the supply of electricity in accordance with the specifications, general conditions, plans, and form of tender, which can be obtained at the office of Mr. J. W. Cockrill, A.R.I.B.A., borough surveyor, Municipal Buildings, Great Yarmouth. A deposit of £2. 2s. must be made with Mr. W. J. Nutman, borough accountant, Municipal Buildings, Great Yarmouth, for the specifications and plans, which deposit will be returned on the receipt of a *bonâ fide* tender. Sealed tenders, endorsed "Electricity," to be delivered at the office of the town clerk not later than February 19.

The Acton Hill Works.—On Saturday last the Acton Hill Electrical Engineering Works wore an unusually festive appearance, Captain Ronald Scott having arranged to give a tea and entertainment to 200 of the poor children of Acton in order to celebrate the recent marriage of his brother, Captain Percy Scott, R.N., with Miss Roma Dixon-Hartland, eldest daughter of Sir Dixon-Hartland, Bart., M.P. Captain Ronald Scott was ably assisted in dispensing his hospitality by Miss Walker and some lady teachers from All Saints' Church, South Acton, and the following members of his works: the Hon. Verney-Cave and Messrs. Garratt, Bircher, Squire, and Bouquet. The works were electrically lighted in a specially brilliant manner for the occasion.

Anglo-Amer'can Telegraph Company.—The directors, in their report, propose further dividends of 13s. 6d. per cent. on the ordinary stock, and of £1. 7s. per cent. on the preferred stock, making, with the previous payments, total distributions of £2. 11s. per cent and £5 2s. per cent. respectively for the past year, leaving £844 undivided. It is further stated that, "in view of the age of the Company's cables, and the necessity for assuring the efficiency of the service, the directors, after much and anxious deliberation, have decided to lay a new cable from Ireland to Newfoundland in the coming summer." A contract has been entered into with the Telegraph Construction and Maintenance Company for the manufacture and laying of 1,955 miles of cable between Valentia, Ireland, and Heart's Content, Newfoundland, for the sum of £450,000, which will be paid out of the renewal fund.

Eastern Telegraph Company, Limited.—The revenue for the six months ended September 30 amounted to £369,967, from which are deducted £98,106 for the ordinary expenses and £31,906 for expenditure relating to repairs and renewals of cables, etc. After providing £6,753 for tax, there remains £233,201, to which is added £1,133 brought forward, making a total available balance of £234,334 From this balance there have been paid—interest on debentures and debenture stock, £27,697; dividend on preference shares, £20,384; two interim dividends of 2s 6d. per share each on the ordinary shares. £100,000; totalling £148,081, and leaving £86,252, which is carried forward. Under the terms of a contract dated June 17, 1893, with the Portuguese Government, the Brazilian Submarine Telegraph Company and this Company have secured an additional 10 years of their respective privileges under existing Portuguese concessions. To obtain this extension, this Company and the Brazilian Submarine Telegraph Company undertook to connect Lisbon and this Company's general system with the Islands of the Azores, and the two companies hold a large proportion of the shares in the Europe and Azores Telegraph Company which has been formed to work the line. The new cable was laid in August last. A cable has also been laid from Zanzibar to Seychelles and Mauritius.

Cardiff.—Mr. R. H. Fletcher, the local representative of Mr. Massey, electrical engineer to the Cardiff Corporation, expects that the arc circuit will be completed and the streets of the centre of the town lighted by electricity by the end of March or the beginning of April next. In St. Mary-street lamps 22ft. high will be fixed in the middle of the road; but in Queen-street they will be placed alternately on either side of that thoroughfare. The reason for the latter arrangement is the existence of a double set of tram lines down the centre of the street, the moving of which, if practicable, would entail great expense. In St Mary-street the tram lines run, for the most part, along one side of the road only. Pipes for the cables are laid on the north side of Queen-street, on both sides of Castle-street, on the north side of Duke street, and down the east side of St. Mary-street. The idea is to first complete the arc circuit for the lighting of the streets, after which private applications for the electric light will be dealt with. At the central station on Canton Common the underground work is complete—the flues, etc., and the three boilers are being built in their settings. The whole of the foundations are ready to receive the engines, and the building is practically finished. A travelling crane is in position ready to put down the machines which will generate the electric current.

Edinburgh.—A memorial was presented at a meeting of the Town Council on Tuesday by proprietors, merchants, and inhabitants of the Lawnmarket asking that that thoroughfare should be included in the area to be lighted by the electric light. The memorialists pointed out that, owing to the height of the pavement above the roadway, a badly-lighted street like the Lawnmarket would be attended with danger to the public. Mr. Cameron supported the memorial, and Mr. Mackenzie said that four lamps would be required to light the Lawnmarket, and the committee had at least two still to dispose of. The memorial was remitted to the Cleaning and Lighting Committee, along with a notice of motion by Mr. Waterston to consider the electric lighting of the Canongate. Messrs. Mortimer and Auldjo Jamieson moved that it be remitted to the Cleaning and Lighting Committee to consider and report as to the advisableness of lighting George-street, St. Andrew square, and the cross streets from Princes-street to George-street with the electric light. The Lord Provost said the Council had recommended the lighting of only the main thoroughfares of the city with electricity, and if they once departed from that principle they would have councillors from one district fighting against those from other wards, and no one could say where it would end. Mr. Mackenzie said it would cost £1,000 to light George-street and St. Andrew's-square, and for streets where there was so little traffic at night, he did not think the expenditure would be justified. The motion was remitted to the committee. On the motion of Mr. Mackenzie, it was remitted to the Lord Provost's Committee to consider and report on the charges to be made for the supply of the electric light to citizens.

Northampton.—What is termed an electrical soirée was held on Tuesday and Wednesday in the Town Hall. The Mayor, at the opening of the soirée on Tuesday, expressed pleasure at being called upon to open that exhibition, which, so far as he knew, was the first electrical exhibition that had taken place in the town. He believed the promoters of the exhibition had in view the bringing before the notice of the public of Northampton some of the uses of electricity with which they

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were not quite familiar. The speechmaking having ended, the company proceeded to witness the various experiments. The old Council-chamber was occupied by electrical appliances, including motors and cooking-stoves. Here Mr. H. J. Dowsing, M.I.E.E., of Messrs. Crompton and Co., explained how electricity can be used in three distinct ways in the household. First, he dealt with lighting, pointing out the absolute purity of the light and its safety, making several experiments to show how safe it really is. Next, Mr. Dowsing showed how the same electricity can be used as a motive power for carrying out the light operations such as cleaning knives and forks, grinding coffee, driving a washing-machine and a mangle. The production of heat was also explained, and in order to demonstrate how simple is the machinery by which electricity for lighting purposes can be generated exhibited a small dynamo, which could be driven by hand to light a small lamp. A small electric motor for driving a ventilating fan, and a coffee-grinding machine worked by electricity attracted much attention. Ladies were invited to have their hair curled by electricity by means of the curling iron heaters, and gentlemen were invited to have their hats ironed. Hot-plates for boiling, stewing, grilling, and carrying out all the operations required in the kitchen were on view, and Mrs. Dale, in the presence of a good audience, grilled some steaks, cooked tomatoes, and various kinds of fish and pastry, including Shrewsbury cakes and cocoanut buns. Mr. Dowsing repeated the lecture on cooking which he gave at the electric light works on Friday. By permission of the National Telephone Company, a telephone placing visitors in communication with Lincoln, Nottingham, Sheffield, Manchester, Leeds, Bradford, and the North of England, and London and the South was in operation. Those who so desired could listen to theatrical performances, the pantomime at the Leicester Opera House being heard very clearly.

Action about Incandescent Lamps.—At the Sheffield County Court last Friday, before his Honour Judge Ellison, the Sheffield Café Company brought an action against William Bakewell, electrical engineer, Shortridge-street, Attercliffe, to recover £10. The company originally claimed £9. 10s. for 76 lamps given up to the Edison and Swan Electric Light Company; £5. 5s. charges of Messrs. Ashurst, Morris, Crisp, and Co., solicitors to Messrs. Edison, Swan, and Co., and £3. 3s., charges of Messrs. Clegg and Sons, Sheffield. This made a total of £17. 18s., but the Café Company abandoned £7. 8s. of their claim and reduced it to £10. Mr. W. E. Clegg was for the plaintiffs, and Mr. A. Neal appeared for the defendant. According to the statement of Mr. Clegg, the defendant in June, 1892, showed the manager of the company a Zurich incandescent lamp. The cost of this was 2s. 4d., while the cost of the Edison and Swan lamp was 4s. Eventually it was agreed that the defendant should supply what lamps were required at 2s. 4d. each, and he supplied to the Company about 140 lamps. On the first of May, 1893, Messrs. Ashurst, Morris, Crisp, and Co., who were the solicitors to the Edison and Swan Electric Light Company, wrote to the plaintiffs, and stated that the Zurich lamps were an infringement of the patent of their clients. Eventually, rather than fight the Edison and Swan Company plaintiffs gave up 83 lamps, and paid the solicitors' costs, and they now sought to recover £10 from the defendant. Mr. Neal explained that the manager of the Café Company was shown two lamps—the Edison and Swan lamp and the Zurich lamp—and he chose the latter, no doubt, because it was cheaper. His Honour said that, according to decisions, he thought it must take it that an article which was an infringement of a patent was an injurious article. Mr. Neal: There is no evidence that it was an infringement of a patent. Mr. Clegg said if his friend raised that point he must have someone from the Edison and Swan Company to show that this Zurich lamp was an infringement of a patent. Mr. Neal replied that Mr. Whitehead, the manager to the Café Company, was shown the real Edison lamp and the Zurich lamp, and he chose the latter. Mr. Clegg said it was supposed that the defendant, as an electrical engineer, knew all about electrical patents, and would not offer an article for sale which was an infringement of an existing patent. After further argument his Honour decided to adjourn the case in order that he could look up the decisions on the points raised, and also to enable Mr. Clegg, if he thought fit, to call witnesses to prove that the lamps sold to the plaintiff company were an infringement of the patent of the Edison and Swan Electric Light Company.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	2⅜
— Pref.	—	2¼
Charing Cross and Strand	—	5
City of London	—	11½
— Pref.	—	13¼
Electric Construction	—	1¾
House-to-House	5	2
India Rubber, Gutta Percha & Telegraph Co.	10	22½
Liverpool Electric Supply	5	6¼
	3½	4⅝
London Electric Supply	5	1
Metropolitan Electric Supply	—	8⅜
National Telephone	5	4⅜
St. James', Pref.	—	8½
Swan United	3½	3½
Westminster Electric	—	5½

PROVISIONAL PATENTS, 1894.

JANUARY 15.

854. **Electrical tramways.** Thomas Elcoate, Chestnut House, Norton, Stockton-on-Tees.

863. **Improvements in incandescent electric lampholders, ceiling roses, and other electric fittings.** William McGeoch, jun., Andrew Jackson McGeoch, and Frank Geere Howard, 108, Argyle-street, Glasgow.

908. **Improvements in apparatus for heating cylinders and parts of hydraulic machinery by the aid of electricity.** William Lawrence Williams, Walter Thomas Goolden, and Henry Willock Ravenshaw, 1, Queen Victoria-street, London.

916. **Improvements in electrical measuring instruments.** Haydn Thies Harrison, 46, Lincoln's-inn-fields, London.

JANUARY 16.

923. **Improvements in high and low tension electric fuses.** Benjamin Deakin, 2, Raeburn-street, The Avenue, Brixton, London.

993. **Improvements in brushes for dynamo-electric machines.** Pierre Joseph Charles Carron, 45, Southampton-buildings, Chancery-lane, London.

1003. **Improvements in electric railways.** Henry Harris Lake, 45, Southampton-buildings, Chancery-lane, London. (Edward Hibberd Johnson and Robert Lundell, United States.) (Complete specification.)

JANUARY 18.

1087. **Improvements in methods of electric haulage.** Benjamin Howarth Thwaite and George Cawley, 95, Finsbury-pavement, London.

1110. **Improvements in automatic electric governors for prime or other motive-power engines.** Edward Joseph Bonner Lowdon, 41, Reform-street, Dundee.

1113. **Improvements in or in connection with dynamo-electric machinery.** Wilfrid L. Spence, The Elms, Seymour-grove, Manchester.

1115. **Improvements in safety devices for electrical circuits.** Albert Essinger and Thomas Harden, 55, Chancery-lane, London.

JANUARY 19.

1164. **Improvements in armatures of dynamos and electric motors.** Harry Penn and Loftus Lowndes, 25, Lordship-road, Stoke Newington, London.

1169. **Improvements in electric arc lamps.** George Hind Nisbett, 248, Stanstead-road, Forest Hill, London.

1199. **New or improved device for operating the buttons or switches of electric bells.** Henry George Farrell, Commercial-street, Sheffield.

JANUARY 20.

1268. **Apparatus for actuating electric switches, gas and water cocks, or the like.** Edwin James Howell, 45, Willow-road, Balsall Heath, Birmingham.

1306. **Improvements in electric heaters.** Edward O'Briern and the Electrical Installation Company, Limited, 53, Chancery-lane, London.

1307. **Improvements in electric switches.** Henry Hayes Cooper and the Electrical Installation Company, Limited, 53, Chancery-lane, London.

1308. **Improvements relating to electromagnetic railway brakes and to brake couplings for railway trains.** Henry Edmond Walter, 24, Southampton-buildings, Chancery-lane, London.

SPECIFICATIONS PUBLISHED.

1890.

873. **Electric supply motors.** Perry. (Second edition.)

1893.

1416. **Electric alarum.** Weygang.

1579. **Electric bells.** Weygang.

1812. **Electric switches.** Sansome and Hawes.

22311. **Storage batteries.** Usher.

22312. **Storage batteries.** Usher.

The Price of Shares.—"During the present month," says the *Financial Times*, "there has been a fair business doing in the shares of the electric lighting and supply companies. The subjoined table will show at a glance the movements which have taken place. It is expected that the reports, which in most cases are now about due, will show favourable results:

Stock.	Price January 2.	Price January 22.	Rise.
Brush	2⅜-⅝	2⅝-⅞	¼
City of London	11¼-½	11¼-½	—
St. James's and Pall Mall	5½-6	6-½	½
Ditto Preference	7½-8½	8-½	¼
Westminster Supply	5-½	5¼-½	¼
Metropolitan Supply	7⅜-8¼	8¼-⅜	½
Ditto Debentures	103-6	104-8	1½

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NOTES.

Derby.—The Lighting Committee of the Town Council last week discussed the question of lighting the streets with arc lamps.

Churning by Electricity.—A "Disc" churn, operated by an electric motor, is now being shown at work at 54, Church-road, Hove.

Aluminium.—On Saturday, at a meeting of the Manchester Association of Engineers Mr. W. S. Sample read a paper on the manufacture of aluminium.

Lambeth.—The Vestry have decided to defer the re-election of the Electric Lighting Committee until after November next, the date of the elections to the district councils.

Station-Lighting.—The new goods station and buildings now being completed for the Great Northern Railway Company at Farringdon-street are to be lighted by electricity.

Lighting of Dredgers.—The large dredger now being built and engined by Messrs. Lobnitz and Co., of Renfrew, is to be lighted by electricity, and to be equipped with a search-light.

St. Pancras.—The Vestry have resolved to continue to pay to Prof. Robinson 4 per cent. on all distinctly electrical work carried out under his direction in connection with the King's-road station.

Southampton.—The council of the Hartley Institution have accepted an offer from Mr. W. H. Preece of scientific apparatus for the proposed engineering laboratory in connection with the institution.

New Book.—A new engineering compilation of 600 pages and with 700 illustrations, entitled "The Engineers' Year-Book," by Mr. H. R. Kempe, is about to be issued by Messrs. Crosby Lockwood and Son.

Telegraphy.—Mr. J. Henniker Heaton, in a letter to the *Times*, complains of the persistence of the postal authorities in the policy of levying the high rate of twopence per word on cablegrams to France.

Large Search-light.—"Wainhouse's Observatory," on the ridge of Skircoat, Halifax, is being equipped with an electric search-light of 25,000 c.p., whilst arc lamps are being placed on the ornamental pediment.

Tramcar Accident.—It is reported from San Francisco that a tramcar accident occurred there on Sunday. Whilst one of the electric tramcars was running it was overturned. Twenty-one persons were injured.

Proell's Expansion Apparatus.—Pamphlets setting forth the principle and advantages of Proëll's automatic expansion apparatus for steam-engines have been issued by Mr. H. Kühne, of 25-35, New Broad-street, E.C.

Telegraphy on the Congo.—It is stated that the Congo Free State has decided to construct a telegraph line from Boma to Lake Tanganyika. The line is to be completed in sections, the first portion running from Boma to Kenge.

Leeds Tramways.—The mayor has convened a meeting to consider the advisability or otherwise of the Corporation leasing the tramways to a company. The cost of haulage of the electric cars is said to be between 5½d. and 6d. per mile run.

Coventry Electric Cars.—The Warwickshire County Council recently decided, if the city of Coventry withdrew its opposition to the transfer of the tramway to the Coventry Electric Tramway Company, Limited, not to offer any opposition.

Rapid Transit.—A syndicate of railway capitalists, independent of the Wilson Syndicate, is said to be ready to undertake the construction of an underground rapid transit line in New York without the city's assistance.

The Institution.—A paper, entitled "Some Notes on the Electric Lighting of the City of London," by Major-General C. E. Webber, C.B., M.I.C.E., past-president, will be read at an ordinary general meeting to be held on Thursday next, the 8th inst.

Junior Engineering Society.—A paper on "The Construction and Working of Electromotors," by Mr. A. H. Dykes, A.I.E.E., will be read and discussed at a meeting of this society, to be held on Friday next, the 9th inst., at the Westminster Palace Hotel.

Conversazione.—The first annual conversazione of the Junior Engineering Society in connection with the Great Western Railway Mechanics' Institution at Swindon, and to which further reference is made in another column, was a most successful and interesting gathering.

Great Britain and the Antwerp Exhibition.—A meeting promoted by the London Chamber of Commerce, and presided over by the Lord Mayor, has passed a resolution welcoming the formation of a representative British section for the Antwerp International Exhibition.

Students of the Institution.—A students' meeting of the Institution of Electrical Engineers will be held at 28, Victoria-street, S.W., this (Friday) evening at 8 p.m. Experiments illustrative of the paper read at the last meeting on "Multiphase Currents and their Application," by Mr. C. S. Drysdale, will be made.

Newcastle.—The Town Council have referred to the Tramways Committee a communication from the Brush Electrical Engineering Company. The latter, in reference to statements that the Corporation were considering the question of changing the method of working the tramways, suggested the suitability of electric traction for the purpose.

The Proposed Cable Conference.—Sir Thomas M'Ilwraith arrived at Ottawa last week from the Pacific coast, and he expects to remain in Canada for some weeks before leaving for Japan. He learned that the proposed conference at Ottawa in reference to the proposed Pacific cable scheme had been postponed, but he is satisfied that arrangements will be effected for holding the conference of colonial representatives either in Canada or Australia.

An Advertising Novelty.—A novelty in the way of advertising is seen nightly on the New York streets. It consists of a handsome wagon, drawn by four horses, and brilliantly illuminated with electric lights. The edges of the wagon are outlined with lamps, and each horse is equipped with two lamps—one on the saddle and one on the top of his head. A storage battery is carried in the wagon, and the illumination is brilliant and attractive.

Lecture.—At the Midland Institute, a few days ago, Prof. Silvanus P. Thompson, F.R.S., lectured to a large audience upon "The Supply and Measurement of Electricity." In the course of his remarks the lecturer expressed the conviction that the time was not far distant when corporate bodies would have to become the purchasers of the temporary monopolies which they had allowed private companies to gain in the matter of electric supply.

The Government and Telephony.—It is reported that the agreement between the National Telephone Company and the Post Office has now been concluded, and that it will be laid on the table of the House of Commons when it reassembles. It is stated that Mr. Provand will meet with a good deal of support within the House if he moves for the appointment of a commission (to which reference

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was made in a previous issue) to investigate the case for the municipalities, and also for the acquisition of the National Telephone Company's undertaking by the State.

Society of Arts.—On Monday, at 8 p.m., the third Cantor lecture on "The Detection and Measurement of Inflammable Gas and Vapour in the Air," by Prof. Frank Clowes, D.Sc., will be delivered. On Wednesday, at 8 p.m., a paper on "Automatic Balance of Reciprocating Machinery, and Prevention of Vibration," by Mr. W. Worby Beaumont, will be read. On Thursday, at 4.30 p.m., a paper will be presented on "Telegraphic Communication Between England and India: Its Present Condition and Future Development," by Mr. E. O. Walker, C.I.E., M.I.E.E., formerly of the Government of India Telegraph Department. The latter meeting will be held at the Imperial Institute, S.W.

End of the "Medical Battery" Company Prosecution.—At Marlborough-street Police Court, on Wednesday, the charges of conspiracy to defraud against Cornelius Bennett Harness, of the Medical Battery Company, Limited, James Montgomery McCully, and Charles Beavington Hollier were further heard. Mr. Avory, having called several other witnesses for the defence, Mr. Hannay, the magistrate, said he understood that Mr. Avory had other witnesses, but he did not intend to ask him to call them. He held that there was no probability of a jury convicting the defendants, and he should discharge them. The defendants were then discharged, a week being allowed the prosecution to say if they will take the responsibility of preferring an indictment at the sessions.

Forthcoming Visit of Edison.—Early in the coming spring Colonel Gouraud will have as his guest at Whitehall Court Thomas A. Edison, who is coming to take a rest in Europe this summer. Colonel Gouraud has devised what he calls a "vigintave kettledrum," at which the number of invited guests is limited to 20. These receptions will take place every Wednesday and Saturday afternoon. At the first "vigintave," a young American inventor, Mr. Burdick, of Chicago, exhibited his electro-pneumatic art brush, an instrument by which an artist is enable to produce the most delicate effects of stippling without actually touching the canvas. The paint is sprayed on to the canvas through a fine-pointed tube attached to a compressed-air bellows. Mr. Burdick gave an exhibition of his instrument at the Imperial Institute a few nights ago with considerable success.

The Antwerp Exhibition.—As noted elsewhere, the Electrical Trades Section of the Chamber of Commerce has decided not to advise or promote concerted action amongst the leading members of the industry as regards British exhibits in the approaching international show at Antwerp, leaving to individual enterprise the expenditure of time and trouble in sending goods over as may be thought advisable. So far as the developments of electricity are concerned, although there is to be a Galerie d'Electricité, no very exhaustive departments or classification seems at present to be attempted. In Section VI. of the schedule, Class 24, "Railway Plant," electric railways are included, and Section VIII. is confined to electricity, with the following sub-divisions: Class 28—Batteries, dynamos, transmission of electric force, lighting, production of the electric current, conductors, present knowledge of the subject, industrial application of electricity, transmission of the force, motors, traction engines, chemical electricity, different applications; Class 29—Telegraphs, telephones, and electric clocks, electric signalling, levels for ascertaining pressure of atmosphere, etc.

Chemical Potential of Metals.—Mr. W. D. Bancroft, in the columns of a German contemporary, treats of the chemical potential of metals. The author has investigated the difference of potential between the metals magnesium, zinc, cadmium, tin, lead, bismuth, mercury, and platinum in various salt solutions. He finds that when the pairs of metals are selected from magnesium, zinc, cadmium, tin, lead, and bismuth, neither the positive nor the negative iron of the salt solution has any effect on the E.M.F., which also remains constant although the dilution varies from 10 to 1,000 litres. When mercury forms one pole of the combination, the influence of the negative ion of the salt solution is very marked, but concentration does not influence the E.M.F. In the case of platinum, the difference of potential depends on the concentration of the salt solution when the dissolved salt is a haloïd. This is possibly due to the tendency of platinum to form platinochlorides, etc., in which the platinum is not present as an ion. It would appear, although the numerical agreement still leaves something to be desired, that the E.M.F. of the combination $M_1 \mid RX \mid M_2$ is identical with that of the reversible combination $M_1 \mid M_1X \mid M_2X \mid M_2$.

Action in Connection with the Niagara Falls Scheme.—An action has been brought against the Cataract Construction Company by Prof. Henry A. Rowland, of Baltimore, for £6,000, claimed as the value for services rendered in connection with the electric power transmission at Niagara. It appears that after the plans of the engineers of the Cataract Company had been formulated they were submitted to Prof. Rowland for his opinion as to their feasibility, and after a careful study he submitted, it is said, an opinion embodying improvements differing widely in character from the methods and designs indicated in the original plans. For this opinion Prof. Rowland presented a bill of £2,000 to the company, which was considered excessive and which was only honoured to the extent of £750. The action is a result of this. Prof. Rowland claims that practically all of his suggestions were adopted by the Cataract Company, and that by so doing they saved a large amount of money; and hence he considers his charges no greater than the magnitude and importance of the work warranted him in making them. Some eminent electrical engineers will appear on both sides, and it is believed that some interesting details relating to the Niagara project will be brought out during the trial.

Electromotive Forces of Insoluble and Complex Salts.—Dealing with this subject in the *Zeit. Physikal. Chem.*, Mr. K. Zengelis states that Ostwald obtained results for silver salts in agreement with the following general principles: Insoluble and complex salts, on account of the small concentration of their metallic ions, show considerable deviations from the calculated value of the E.M.F. of two-fluid combinations in which they occur, the deviation increasing with the decreasing solubility of the salt. Salts soluble in the complex compounds have a smaller deviation, and salts insoluble in them a greater deviation, than the complex compounds themselves. The author has tested the validity of these rules in the case of a number of slightly soluble and complex compounds of silver, copper, lead, nickel, and cobalt, and has obtained results in harmony with them. In the case of the phosphates of lead, cadmium, and silver, the E.M.F. gradually diminishes on standing, owing probably to the formation of basic salts. Similar diminutions were observed with the carbonates, and to a smaller extent with the arsenates. Where no basic salt is formed, as in the case of silver carbonate, the E.M.F. remains constant. With sulphides, an increase of the E.M.F. was sometimes noticed, probably due to the transformation of the hydrosulphides at first formed into normal sulphides.

Mechanical Traction in Liverpool.—Sir D. Radcliffe, chairman of the Liverpool United Tramways and Omnibus

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Company, referred at a meeting of the latter on Saturday to some remarks of Mr. Munro about mechanical haulage. The chairman said that he hoped it might become the haulage system in Liverpool before long. Everything had been done to give mechanical haulage a fair trial. When Colonel Beaumont brought his system of haulage by compressed air, they gave him every facility for trying it. He said he would do it for 3d. per mile, and he (Sir David) ventured to suggest to him that probably 4½d. per mile would be the sum that the company would be glad to give. After a trial extending over some time it was a failure. The colonel wanted 5d. per mile, and then 6d. They subsequently had two or three trials of electric haulage, and this they found would cost 7d. per mile, and in addition the company would have been charged £1,680 for each engine and car. Seeing that the company had two or three hundred cars they would have to raise the sum of half a million of money to adopt the system. They did not shut their eyes to the fact that mechanical haulage would be much better for them if they could get it at something like a reasonable price. The company was a commercial concern, and it was no use their trying fads involving them in such expenses as had been indicated.

The Electrical Trades Section — London Chamber of Commerce.—On Monday last there was held at the Chamber of Commerce the meeting of this section that was adjourned from the previous week; the attendance, however, was still not very great. Regarding the three principal matters on the agenda paper, it was decided in the first place not to attempt any united action on the part of the section or industry with reference to the display of British goods at the Antwerp Exhibition to be opened in May next. Individual firms or interests who consider it worth while to incur the expense will, of course, meet with every possible assistance both from the section and from the Chamber of Commerce, but from a general point of view it was thought that hostile tariffs had so injured the continental market for British goods that the game would not be worth the candle. With reference to the second matter—the report of the Electric Traction Sub-Committee—the chairman (Mr. Garcke) had nothing more to say than we chronicled last week, except that probably all the interests involved would be asked to meet the Board of Trade in order to discuss the points at issue. The third item that was dealt with related to the formation of a permanent parliamentary committee; and with regard to this, it was decided not to attempt this at present, owing to the possibility of conflicting interests being involved.

Electromotive Forces of Polarisation.—M. Le Blanc, in the *Zeit. Physikal. Chem.*, gives a continuation of his investigations in this direction. From a further study of the E.M.F.'s of polarisation in salt solutions, the author finds that at the decomposition point in a solution from which a metal is deposited on the cathode, the E.M.F. of polarisation at this electrode is equal to the electrolytic solution pressure of the metal in the solution, and is independent of the nature of the electrode, provided it is not attacked. The numerous apparent exceptions to this simple rule are referred by him to the development of gases at the electrodes, in which case the E.M.F. necessary for their liberation depends in great measure on the nature and condition of the electrodes employed. By suitable arrangement of his apparatus, he was able to show that in many of these cases the solutions exhibited the normal behaviour, and that the electrolytic decomposition and formation of water (by means of a gas battery) is a reversible process. Salts of zinc, cobalt, nickel, and cadmium have a high decomposition point, and usually deposit the metal without evolution of hydrogen. This behaviour is due to special circumstances, and it is shown that under appropriate conditions hydrogen appears at the cathode, and not the metal. The assumption that the atoms of gases contain a greater amount of energy than the molecules is considered by the author to be untenable. They form two states of matter with practically the same energy content, the difference between them being that the atoms enter into chemical action with a great velocity of reaction, which is only approached by the molecules when a catalyst is present.

Explosions of Gas in Manholes.—In our last issue reference was made to the report prepared by Mr. W. H. Preece for the Commission of Sewers on the recent explosions in manholes belonging to the City of London Electric Lighting Company in Ludgate-hill and St. Paul's-churchyard. Mr. W. H. Preece states that the two explosions occurred simultaneously in a box in Creed-lane and in another nearly opposite the premises of Messrs. Howell in St. Paul's-churchyard, a distance of 55 yards apart. The effect of the explosion was to blow the covers of the boxes to a considerable height in the air. One of them broke in falling, while the other made a hole in the pavement and stood upright in the aperture it made. One person (a boy) was injured. A careful examination of the boxes revealed the fact that the explosions were caused by an accumulation of coal gas and air in the pipes and boxes. The cables carrying both the public and private current were in good condition, and the electrical tests proved that there was no leakage on the circuit to cause the accident. At the time of the explosions some of the company's men were working at a distance of 50 yards away, and they were using a red-hot plug or "rat." It was possible, Mr. Preece says, that this red-hot iron might have ignited the gaseous mixture by passing upwards into the boxes referred to. If it were not for leaky gas-pipes no accumulation of gas could take place; but the mains are, he says, notoriously leaky. The City of London Electric Lighting Company, as mentioned last week, has since introduced a system of inspection of boxes, and by extra vigilance on the part of the employés it is hoped that an immunity will be secured from such explosions in future.

The Prize for an Improved Electric Traction System.—"If the enquiries we receive are a criterion of the interest taken by electrical inventors in the contest for the £10,000 prize offered by the Metropolitan Traction Company of New York for a system of street railway traction as economical as the trolley," the *Electrical World* says "that company will be most abundantly supplied with projects. While thus inventors are presumably responding with alacrity to the demand made upon them, an obligation rests with the company to meet them in a similarly liberal spirit, or at least to give assurance that their labour will receive the consideration that it deserves. If, however, the date first given, March 1, before which a working exhibit must be placed in operation, is adhered to, there is no chance, except under extraordinarily favourable circumstances, for any competition under the terms given. We learn that the Waddell-Entz Company has formally entered the competition with its storage-battery system, which has been working so efficiently on the Second-avenue line, but this required no preparation on its part on account of having a practical plant already in operation. We also learn that a system based upon contacts made by means of magnets is preparing to compete, but this also was in experimental shape before the prize was offered. Unless the time of competition is considerably extended these two may be the only systems in shape to compete, and thus no benefit will be derived from impetus given to invention by the offer of the prize. While we believe any suspicion as to ulterior motives on the part

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of those who offered the prize would be most unjust, yet the discussion over the alleged manner in which the Niagara Construction Company benefited from information obtained in a similar manner would tend to give colour to charges by a disappointed inventor based upon the same grounds, if the competition were brought to a close before an opportunity for trial were afforded. We trust that the Metropolitan Traction Company will see the impossibility of accomplishing its purpose within the time limit given, and offer an extension sufficient to enable any inventor who can enlist the necessary support to put his system to a practical test. By so doing it will not only derive the benefit desired, but perform a public service of no mean proportions."

Electricity and Plant Growth.—Dr. G. J. Romanes has given the results of a long series of experiments on mustard seedlings exposed to constant electric light and to interrupted flashes respectively. The plants were grown in the dark till they reached a height of 2in., and a thick plate of glass was placed between them and the electrical apparatus. At a temperature of 70deg. F., and in a dark moist camera with a shutter (which by being opened exposes the plants to the light), vigorously growing seedlings began to bend to the electric sparks 10 minutes after exposure, and bent through 45deg. in as many minutes. In an hour and a half the leaves were bent horizontally to the light. There is a more rapid rate of bending than can be produced on the same pot of seedlings when the side formerly protected is uncovered and exposed for a similar duration of time, either to constant sunlight or to constant diffused daylight. This is the case even if the sparks (or flashes) succeed one another at intervals of only two seconds. Thus the heliotropic influence of electric sparks (or flashes) is greater than can be produced by any other light. Dr. Romanes then exposed one pot of seedlings in a camera to the constant light of a Swan burner, and another pot of similar plants in a second camera, placed at the same distance from the same source of light, but provided with a flash shutter working at the rate of two seconds intervals. The rapidity with which the bending commenced, and the extent to which it proceeded in a given time after commencement, were found to be considerably greater in the seedlings exposed to the flashing light than to the constant light. In his next set of experiments he found that the bending of the seedlings occurred within 15 to 30 minutes, if bright sparks were supplied at the rate of only one per minute. It is strange, however, that these remarkable results are not accompanied by the formation of any particle of chlorophyl. He has used thousands of plants in his work, yet he has never seen the slightest shade of green tinging the etiolated seedlings which had bent towards flashing light. On one occasion he kept a stream of a hundred sparks per second illuminating some mustard seedlings continuously for 48 hours; and, although this experiment was made for the express purpose of ascertaining whether any chlorophyl would be formed under the most suitable conditions by means of flashing light, no change of colour in any of the seedlings was produced.

Lighting of Halifax.—The Municipality, who are laying down plant for the supply of the electric light, only obtained in October the sanction of the Local Government Board to borrow the £30,000 needed for providing the station, but a site for the central station has been acquired, the excavations for the cables have been commenced, and the plant has been ordered. Mr. Wilmshurst, the electrical engineer to the Corporation, decided upon the high-pressure alternating-current system. At first the Corporation contemplated utilising for the purposes of the central station the Salvation Army Barracks, which they own; but, owing to its distance from railway and stream, this site was abandoned for the Park Mills site in Foundry-street, on the right bank of the Hebble brook, from which water for condensing purposes can be obtained, and close to the railway, from which it is proposed to run trucks into the top of the boiler-house and shoot the coal direct. The area of these conveniently-situated premises is about 5,000 square yards, and upon the site are to be erected boiler and engine houses, which it is proposed to fit up at present with three boilers, four engines, and two alternating-current dynamos. The works, however, will be so constructed as to be capable of accommodating additional plant when extensions are necessary. The plant will consist of three Lancashire boilers, 30ft. by 7ft. 6in., pressure 140lb. per square inch. fitted with mechanical stokers, to be supplied by Messrs. Yates and Thompson; one Green's economiser; two compound horizontal condensing engines of 200 i.h.p. each, one of 100 h.p., by Messrs. Pollett and Wiggell; two compound horizontal non-condensing engines of 20 h.p. each, by Messrs. Robey; two alternating-current dynamos of 100 units each, giving 50 amperes at 2,000 volts, one of 50 units, by the Electric Construction Company; two exciters capable of exciting three alternators and a complete switchboard, by Messrs. Fowler. Indiarubber cables, supplied by Messrs. Siemens, are to be drawn through pipes. At convenient points sub-stations will be constructed, in which transformers, made by Messrs. Parsons, are to be placed. The current is to be generated at 2,000 volts, and carried by high-pressure mains to the centre of the town. There the current will be transformed by means of transformers before entering the houses. Some 12 miles of streets are to be opened at once, and 35,000 yards of cable laid underground. The work is to be rapidly pushed forward, with the view to the works being opened in June or July next. The supply of current will be charged by meter.

After-Glow in Exhausted Bulbs.—An article on this subject by Messrs. H. M. Martin and W. H. Palmer, jun., appears in the *Electrical World*. The authors state that having failed to note in any communication on the subject of the phosphorescence of exhausted bulbs in a field of high potential and frequency any mention of what, for want of a better name, may be called the "after-glow," they are led to believe that a brief description of this phenomenon may be of general interest. If an exhausted bulb, having a sealed-in electrode, be held in the hand and approached to a terminal of an induction coil giving moderately high potential and frequency, the whole interior of the bulb will be permeated by a phosphorescent glow; if, now, the bulb be slowly withdrawn from the field of excitation, the degree of luminosity will gradually diminish till a point is reached beyond which the intensity of the glow, now greatly attenuated, is practically unaffected by any further increase in distance from the terminal. It is this glow, entirely independent for its perpetuation of the field in which the bulb was charged, and continuing, they believe, until electrical equilibrium has been established between the rarefied gas and the electrode of the bulb, that we have called the "after-glow." That it is thus independent of the field of excitation may be proved by shutting off, after the "after-glow" has been established, the exciting current of the induction coil, when the glow will be entirely unaffected and continue, practically, for the same length of time as when the coil is in action. When the glow has become almost imperceptible it may often be stimulated into renewed life by shifting the position of the fingers on the surface of the bulb. After this has been done, and the glow has again died away, a single bright flash may be obtained by touching with one finger the projecting end of the sealed-in electrode. That the hand of the experimenter is a factor

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in these effects may be shown by laying the glowing bulb on a table; the glow, though not extinguished, becomes very faint, especially if no object of capacity be near. The bright flash may still be obtained by again picking up the bulb and discharging as explained. They have repeatedly charged a bulb, shut off the primary current from the coil, carried the bulb to a remote part of the house, laid it on a table, and, after picking it up again, obtained a flash on discharging that could be seen some yards away. Lack of apparatus has prevented them from following up these experiments, which are now some months old, but they are valuable, at least, as additional and ocular proof of the electrostatic origin of the "Tesla bulb effects."

Train-Lighting.—Lieutenant Isaac N. Lewis, U.S.A., has succeeded in developing a system of car-lighting which is claimed to possess all the elements of a successful commercial apparatus. The system, which has been tested on a car of the New York Central Railroad, consists essentially of a dynamo driven from the car axle, supplying current to a set of storage cells which furnish current during the period of stopping of the train, and during other periods, as will be explained presently. The dynamo is mounted on the truck, and consists of a four-pole iron-clad machine completely enclosed so as to exclude all dust, and provided with graphite bearing for the armature shaft. The armature is driven directly from the axle by means of spiral spring flexible "belting," which is capable of responding to all the movements of the truck, and thus obviates all necessity for equalising arrangements—such as belt tighteners, idlers, etc., to keep the belt taut. The dynamo, of one kilowatt capacity, weighs barely 2,000lb. and readily finds room on the truck. The current is led into a battery of 11 cells, and these feed the 20-volt lamps, of which there are 12 to each car. The *Electrical Engineer* of New York states that, being driven directly from the car axle, some means must, of course, be provided first for maintaining the direction of the current supplied to the batteries uniform, and at the same time cutting out the dynamo when its speed falls so low as to bring its E.M.F. below that of the storage batteries on the car. Again, the arrangement must be such that the dynamo potential remains practically constant, no matter at what speed the car is running. All these necessary requirements have been worked out with great simplicity by Lieutenant Lewis. A uniform direction of the current is maintained by a pole-changer, while the cut-out, operated by a governor on the dynamo shaft, interrupts the current when the speed of the car falls below that required for the charging of the cells. The uniformity of potential at varying speeds is controlled entirely by a particular and simple method of winding of the dynamo, and no auxiliary regulating apparatus of any kind is employed. Throughout a range of current from 0 to 35 amperes, for which the dynamo is designed, the E.M.F. does not differ one volt, at all the varying speeds, from the point at which the dynamo is cut in up to the maximum. The cutting out of the current from the dynamo below a certain speed relieves the locomotive of all work, when the battery is not charging; as a consequence, also, the dynamo does not act as a drag on the locomotive when starting. The means by which all these operations are performed are exceedingly simple. Besides the car fitted up on the New York Central Railroad, a number of cars on other roads will shortly be equipped, so that the system will soon have a crucial test.

Faulty Wiring of Vessels.—The *Pall Mall Gazette* of Tuesday contained an article entitled "A Needless Ocean Danger," dealing with defective wiring of steamers. Reference was first made to two or three fires on board ship attributed to faulty methods of wiring, and it was pointed out that the ordinary precautions enforced on land are not compulsory at sea, and that inferior work is nearly certain to result sooner or later in an outbreak of fire. Continuing, our contemporary says: "It would be breaking butterflies with steam-hammers to elaborate the importance of sound installations—on land. How much more essential, then, is the soundness of installations employed at sea, where a conflagration is so much more terrible an affair? It might well be expected, then, that specifications for the lighting of ships would in all cases be drawn up by experts. But that is not the case at all. The contractors have practically *carte blanche*, and, as keen competition prevails, the result is the use of shoddy material, improper casing, and indiscriminate fixing. To give instances first of the last-mentioned abuse, conductors are frequently led through cargo holds, where they are inaccessible. They are also led sometimes through coal-bunkers, where explosive coal gas accumulates; while in some cases the safety fuses have been fixed in the bunkers. These safety fuses have porcelain covers, certainly, but a lump of coal would obviously smash such a cover easily. Obviously, when led through such places the conductors should be enclosed in strong metal tubes. If indifferently insulated, they are liable to suffer rapidly from the heat and dampness arising from the cargo and the frequent wetting. Inferior insulations under such circumstances are bound either to melt or to rot away, and the wires thus exposed may corrode through, snap asunder, and cause a fire. Indeed, it is pretty well known among maritime people that small fires are frequent on board electrically-lighted ships. Nobody desires to quarrel with the use of the electric light aboard ships. It is the safest of all illuminants where the installation has been thoroughly well put up. It is a deadly risk when the installation has been badly put up. Surely, then, there should be some expert supervision over all electric light fittings; while at least one engineer and one deck officer of every ship's crew should of necessity be certified as possessing theoretical and practical knowledge of electricity and the dangers involved in its unprotected use. So far as we have been able to learn there has never been any attempt made to secure such special fitness among officers and engineers. In many instances the fitting of electric light installations is put up for competition, the lowest tender securing the contract. The difference between good and bad work means perhaps a divergence of 30 or 40 per cent. in the cost; and the electrical engineer who fits up the installation only has to take care to secure that his work stands the six hours' test which is guaranteed. With this tendering incentive to put in cheap and nasty work, and without any special electrical knowledge being required of any officer or engineer aboard, is it much to be wondered at that the installations are frequently bad? The Board of Trade issues no regulations on the subject, and Lloyd's Registry sends out nothing but a series of 'suggestions.' These 'suggestions' are certainly admirable, but there is no compulsion behind them to enforce them." Our contemporary has before it, "taken from British steamers marked 100 A in Lloyd's Registry (the highest class at Lloyd's, that is), cables which are far from fulfilling those conditions. The Board of Trade have been asked to place in their yearly casualties return a column for electric lighting accidents. Their answer was that the request would receive attention when the next classification of casualties was made, but that hitherto very few accidents had been attributed to the cause mentioned. This suggests," our contemporary concludes, "that the Board of Trade are waiting for the 'Campania' to be burned, with an admiral and a bishop aboard, before they move in the matter."

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THE BOARD OF TRADE AND ELECTRIC TRACTION.

In our issue of November 24 last year we gave the draft regulations issued by the Board of Trade, which regulations, when settled, will control electric traction in this country. We did not hesitate to pronounce some of the draft regulations as unnecessarily stringent, and suggested concerted action among those interested. Action of a kind has been taken, but not so concerted as we could wish it. The London Chamber of Commerce, the Tramways Institute, and the Association of Municipal Corporations have been giving careful attention to the subject, and we understand the latter body has obtained a report on the regulations from Prof. Fleming, who is retained as adviser. Negotiations are proceeding with the Board of Trade, and we understand that at an interview with this authority the view was expressed that in particular cases the regulations might be modified. Prof. Fleming, in his report, after referring to the general views of the opinions given in the parliamentary joint report, points out that the draft regulations are rather calculated to take away what the committee would give than otherwise. He says: "They are in effect so stringent in the limits which they put upon stray or leakage currents that they do in effect, as they stand, render it quite unnecessary for the telephone companies to duplicate their wires, because they throw the whole burden of avoiding the evil upon the tramway companies or owners. The point at issue between the telephone companies and electric tramway companies is really about the right to use the earth as a return. The Joint Committee say in effect: We recommend that neither of you use the earth as a return, but that the tramways shall provide conductivity enough on their uninsulated metallic return to take up all their own current, and the telephone companies shall provide insulation enough by a complete metallic return to prevent any taking up of leakage currents which may exist. The question then is, Have the Board of Trade in their draft regulations laid the burden wholly or too heavily upon the tramway companies or owners, and thereby lightened the burden laid upon the telephone companies? My own impression is, after carefully studying the draft regulations in the light of experience, and in that of the evidence laid before me, that the Board of Trade have set up a standard of perfection for the electric tramway companies which can never be reached in practice, or which can only be reached by an expenditure which will make the enterprise unproductive."

An examination of the regulations clause by clause is given, but at the present moment we cannot give all the criticisms. Suffice it to say that little is discussed as regards paragraphs 1 to 4, but on paragraph 5 the report discusses earth resistance as follows: "The question of what earth resistance is really dependent to a large extent upon what current is to be sent through this earth resistance. If any considerable current, such as 10 amperes, may pass up through these earth connections, then, unless they are very much larger than it would be generally possible to obtain, I doubt whether a terminal earth resistance as low as one ohm is possible. I cannot see the reason for the necessity of this supplementary earth resistance. It is assumed that the conductor in connection with the negative terminal of the generator is an uninsulated earth return. I know by experience that under such conditions the earth return will generally, on the whole, make a much better 'earth' than would be possible by any smaller artificial 'earth.'"

The remainder of the last portion of Clause 5 provides that where no pipe is to be within 6ft. of the earth connection, and the company are unable to obtain permission to connect it with the earth connection, they shall provide a non-conducting screen, so that no current may pass between the pipe and the earth connection without traversing at least 6ft. of earth. If the owners of the pipe are unwilling to allow it to be connected to the negative terminal of the generator, then they themselves ought to take all risks resulting from this non-connection.

Both Prof. Fleming and the committee of the Tramways Institute, as do most other people, find a difficulty in arriving at the meaning of the sixth clause—where the company shall "separate the uninsulated return from the mass of the earth." To all ordinary minds this reads, you must insulate your return. Paragraph (*c*), says the report, "is most delightfully vague. The company are to adopt means for reducing the difference produced by the current between the potential of the uninsulated return at one point and the potential of the uninsulated return at the other point. The difference of potential between any two points on the return depends simply upon the resistance of this return and the current flowing through it. If the Board of Trade chose to define what minimum resistance shall be allowed, well and good; but no person can possibly attach any definite meaning to the clauses, and no tramway company would be able to ascertain when they had complied with it and when they had not."

With regard to the amount of current to earth (*vide* first condition—Clause (*d*), No. 5), that depends upon the resistance of the earth return. The second and third conditions, says the report, "have reference to the direction and magnitude of the E.M.F. between the return and any pipes in its neighbourhood, and they stipulate that the current shall always be from the return to the pipes, and not *vice versâ*; but it is impossible for the current to flow out of the pipes into the return at one place, without flowing out of the return into the pipe at some other place, and unless the uninsulated return has a zero resistance it will not be sufficient simply to connect the pipe system to the negative terminal of the generator. In my opinion, all these two regulations and all their conditions are very academic, and are not based upon a practical experience of what does or may happen in such cases. If uninsulated returns are to be allowed at all (and they have been allowed by the joint report), then there is only one way by which the difference of potential between the ends of this uninsulated return can be connected down, and that is by making the resistance low enough. In order to prevent the escape of the current out of the return into the neighbouring earth, and so, by passing through pipes, producing, in the course of time, electrolysis, the practical remedy would be to embed the return in as highly conducting a soil or surrounding as possible; that is to say, laying an uninsulated return in a broad channel either between the rails or just outside, which is filled in as compactly as possible with gas coke, or some other highly conducting material, but of less specific resistance than the copper of which the return is composed. This connecting envelope, as it may be called, would then be traversed by leakage currents from the return, but it would tend to preserve these currents in a certain channel, and prevent them from escaping into the surrounding earth. Such an auxiliary conductor, as it may be called, would perform the function of limiting the spread

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of the leakage current. Where the tram line forms a curve, something might be done to limit the spread of any leakage current by such a conducting channel, laid on the inner side of the curve, which I believe would have the effect of limiting the spread of the leakage current outwards. I do not think that these regulations, Nos. 5 and 6, are capable of being carried out in practice, neither do I think that it would be possible, as a practical thing, to go exploring about the neighbourhood of every tramway with a galvanometer, to find out if any electric current is flowing to every pipe instead of from any pipe. Where we know pipes are laid down in the neighbourhood of an electric tramway, a far better preservation for the pipe would be secured by thickly tarring or painting the same with a thick coating of pitch when they are laid down."

Clauses 7 and 8 and 9 do not call for much comment, though 7 and 9 are seen to contain unnecessary conditions. It is thought in Clause 10 that one ampere per mile would form a far more practical limit than the 100th of an ampere, and in Clause 11 it is pointed out that one megohm per mile would probably require some great care to attain, but that the insulation resistance of ten megohms per mile of line, returns, and feeders is impracticable. Upon Clauses 18 and 19 the report reads as follows:

"Clause 18 provides five conditions to be complied with in those cases in which the line and return are both laid in a conduit. According to the conditions, the conduit is to be so constructed as to admit of easy inspection and access to the conductors obtained therein. These points are exceedingly vague, unless the Board of Trade define much more strictly what is meant by easy access. It is to be so constructed as to be readily cleared of accumulation of *débris*. The companies may safely be trusted to do this for themselves; also to make such arrangements as to render it secure from water. The conduit, if formed of metal, is to be connected together metallically. This is what would probably be done. The last condition provides for the case of a conduit formed of non-metallic material, and stipulates that a non-conducting screen shall be placed between the conduit and any pipe. This, I think, is an entirely erroneous principle; what ought to be done is to bury the conduit in a deep channel filled with coke, made as highly conducting as possible. I do not believe that any screening of this kind, even if it could be practically carried out, would be effective."

"Clause 19 provides that the company should keep records of their operations. The general effect of these regulations on my mind is to produce the impression that the Board of Trade have taken gas and water pipes and single-wire telephone systems most particularly under their care, and that in the framing of these regulations due weight has not been given to the recommendations of the Joint Committee that as far as possible telephone and telegraph wires were to be protected from stray earth currents by duplicating the telephone and telegraph wires. I think that a great effort has apparently been directed towards preserving gas and water pipes from destruction by stray currents. The only effective way to prevent destructive stray currents from passing out into the general earth is to provide for them a conducting circuit of higher conductivity than the earth, and I think that this can most practically be done by burying the insulated returns in broad channels which are packed in with coke dust. After all, the real question as regards the telephones, even assuming them not to be provided with complete metal returns, is how much current can be sent through the earth without creating a disturbance in telephones in that neighbourhood. On one occasion I had the opportunity of carrying out an experiment on a large scale, in which 100 amperes were passed through an insulated conductor of one ohm and brought back by an insulated return of one ohm resistance, which was well earthed both at home and far end. Under these conditions there was a difference of potential of about 100 volts between the home and distant earth-plates. It was found that about seven amperes flowed back through the earth when the connection at both ends was made to gas or water pipes. But it is obvious it is not safe to draw conclusions from this experiment as to what would universally happen. Suppose we take the case of a tram line three miles long, the maximum current from the return at one time being estimated not to exceed 300 amperes. Supposing that the uninsulated metallic return of half a square inch in section were put down, the resistance of this three miles would be a quarter of an ohm, and the difference of potential produced between the home and far ends of the uninsulated metallic return would thus be about 80 volts at a maximum. Such a difference of potential between two places, three miles apart, might, under some conditions, be sufficient to make a return flow through the earth of about 10 amperes. Where these 10 amperes would go, and what they would do, would depend entirely upon the nature of the surrounding soil, but my opinion is that any practical return through the neighbouring earths might be considerably, if not entirely, limited by embedding this metallic return, or by including it on both sides between either fairly good conducting channels, such as would be formed by filling in the excavation in the ground a few inches wide and two or three feet deep, with coke, well rammed in, and forming, as it were, an auxiliary channel, which would take up the stray current and prevent it from penetrating into the neighbouring soil. The worst point about these regulations is their extreme vagueness, in some respects. The Board of Trade do not define what difference of potential they will allow to exist as a maximum between the points of the earth return, one mile apart. It seems to me that they should do this, and then there would be something definite on which to base calculations. Taking these regulations as I find them, I think it would be very difficult for any consulting engineer who was projecting an electric tramway system to know whether his arrangements would, in the end, satisfy the Board of Trade rules; and unless engineers are able to make such particular determinations, it is perfectly obvious that the effect of the regulations would be to greatly retard commercial enterprise in this respect. Vagueness in regulations of this kind is really, therefore, more fatal to commercial enterprise than great strictness combined with extreme definiteness; because, if we know what standard we have to reach, it is then possible to say whether in the present state of the art we can reach it; but if the conditions to be complied with are characterised by vagueness, then it is not possible to make the necessary determinations of cost with any certainty, or to say whether the scheme will meet with final sanction when completed."

The Tramways Institute has discussed, and we believe its committee has almost settled, the draft suggestions and alterations to be brought before the Board of Trade. Many of these are verbal, many of importance. Thus it would prefer that the word "steady" should be struck out of the first regulation, and "contiguous" take the place of or be added to "between" in the third and fourth. In the fifth clause, authority for modifications should be retained by the Board of Trade, and it might read,

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"shall be placed 20 yards apart or such less distance as may be sanctioned by the Board of Trade." Further, in the same clause, instead of 4in. water-main, read 3in., and add, "unless with the sanction of the Board of Trade." Other suggestions are made, the general tendency being in the direction indicated by Prof. Fleming's report. The same statement applies to Rule 6, where it is pointed out that considerable difficulty is encountered in obtaining earth of the required low resistance of one ohm. In many places the ordinary telegraphic earth-plate has been known to have a resistance of from 50 to 70 ohms. It is thus easily seen that for tramway purposes the difficulty of getting an earth of less than five ohms might be considerable. To the Clause 6 (*i*) it is proposed to add after "10 amperes," "per mile of tramway." With regard to Regulation 7, it is suggested that the atmospheric changes, such as a heavy rainfall or an extremely dry day, may considerably affect the total conductivity of the uninsulated metallic return and the earth in which it is laid. The difference between this conductivity on a wet day and on a dry day may be considerably more than 15 per cent., and it is asked how such a test as is here stipulated shall be applied to eliminate the question of the earth's conductivity under these varying conditions. In Regulation 9, it is pointed out that every connection bar will form an additional point of leakage. This rule and the next are at variance, as is No. 10 with No. 11. Rule 14 is held to entirely do away with all the advantages in the recommendations of the Joint Committee. Rule 19, it is thought, will largely increase the cost of management—for example, many short lines could hardly afford to employ the skilled electrical ability required, and the daily and periodical tests required with sufficient accuracy to be of any value.

We have thus briefly, and we trust not too voluminously, directed attention to the points which appear to various committees prejudicial to electric traction.

FAULTS IN DYNAMOS.

(Concluded from page 121.)

IV. Dynamo Producing Excessive Noise or Vibrations while Running.

When too much noise or excessive vibrations are produced during the running of the dynamo, the cause should be immediately sought for, and a minute examination of the machine made. As a rule, the fault will be found to proceed from the following causes:

A. Loose screws.
B. Jarring of the shaft, from the edge of the drum or the belting against the bearings.
C. Badly balanced armature or drum.
D. Armature jarring against the pole-pieces.
E. Joint of the belt jarring on the drum.
F. Humming caused by the teeth of the armature core when passing the pole-pieces.
G. Bad adjustment of the brushes, causing them to grind against the commutator.

The vibrations may also arise from the dynamo not being firmly bedded.

A. Loose Screws.—A minute examination of all parts kept in their places by screws, such as the bearings, drum, etc., should be sufficient. This defect, which is of frequent occurrence, may be easily prevented if all the screws and movable parts are looked at each time the dynamo is started.

B. Jarring of the Shaft, from the Edge of the Drum or Belting against the Bearings.—A simple examination will show this. It may be remedied with the lathe, by shifting the pulley, or by stretching the belting, and seeing that the latter neither slips on the drum nor rubs against the journal. Sometimes the same result may be obtained by filing the journal and bearing, on the drum side.

C. Badly-Balanced Armature or Drum.—If while the dynamo is running the hand is placed upon the base-plate, strong vibrations, varying with the speed of the dynamo, will be felt. The armature and drum must be examined separately. Lift out the armature, and place it, as shown by Fig. 7, on two perfectly level metallic knife-edges, arranged so that the spindle can turn freely upon them. When this is done the armature should be given a slight impulse backwards and forwards, and if one side is heavier than the other it will have a tendency to descend.

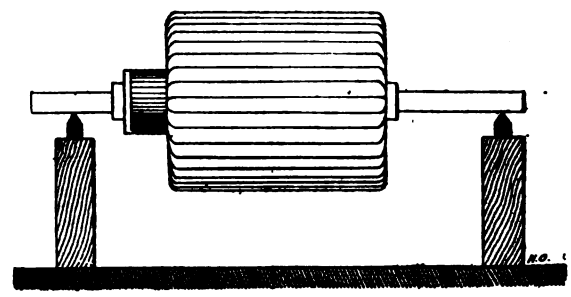

Fig. 7.

When the fault is found to exist in the armature, an equivalent weight of lead may be fixed *very firmly* to the lighter side and the balance restored. If the fault is not in the armature, proceed in the same way with the drum.

D. Armature Jarring Against the Pole Pieces.—Badly-fixed winding may cause this. The armature should be turned and carefully examined to see if it presents any appearance of this, and, above all, if there is a space of at least 1·5mm. between it and the pole-pieces. It will also be seen, if the armature is turned slowly with the hand, if any part of it touches the pole-pieces. Any projecting pieces should be flattened down, or the wires properly secured. If nothing else can be done, the parts of the pole-pieces making friction with the armature should be filed away.

E. Joint of the Belt Jarring on the Drum.—When the joint is badly made, and is thicker than the rest of the belt, it will make a noise each time it passes over the drum. The remedy is to make a new joint, or use an endless belt.

F. Humming Caused by the Teeth of the Armature Core When Passing the Pole-pieces.—With toothed armatures there is always a slight humming when the dynamo is in motion. This noise, however, is not due to a fault, and need not be taken any notice of, except when a dynamo is started for the first time, and only then if the humming is excessive. It may then proceed from defective construction, such as the cross-section of the core teeth being too short, or the ends of the pole-tips being too long, etc.

When the humming increases greatly in a dynamo which has hitherto been in good order, it may be the result of too strong an exciting current. This can be readily ascertained and as readily remedied by increasing resistance in the exciting circuit.

G. Bad Adjustment of the Brushes, Causing them to Grind Against the Commutator.—This can be detected by the ear, and sparking may also occur. Bad adjustment of the brushes, inequalities on the surface of the commutator, brushes too hard (or flinty when use is made of carbon brushes), or at an improper angle, may each and all give rise to considerable noise. Once the cause is ascertained the defect may be remedied by carefully oiling the commutator, re-turning it in a lathe, filing it, or rubbing it down with sand-paper, or, finally, by readjusting the brushes and placing them properly in the brush-holders.

V. The Armature Not Turning at its Normal Speed.

The speed of the dynamo can be found with a speed

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indicator, and as the engine does not alter, it will then be seen whether the speed is reduced or accelerated by the dynamo. The fault may proceed from:

A. Surcharge from the dynamo.
B. Short-circuit in the armature.
C. Bearings too tight or foreign matter in the journals.
D. Friction of the armature with the pole-pieces.

A. SURCHARGE FROM THE DYNAMO.—A reduction of the armature speed is accompanied by excessive sparking and heating of the journals and armature. Furthermore, the belting is unduly tight, and the ampere-meter will show an excess of current. The reduction in speed is merely a result of the fault. For procedure, see "Surcharge from the Dynamo," Part II.

B. SHORT-CIRCUIT IN THE ARMATURE.—This fault is, among other things, characterised by unusual heating of the armature and heavy sparking at the brushes. Proceed as in "Short-circuit in the Armature or Commutator," or as in "Short-circuit in the Winding of the Armature."

C. BEARINGS TOO TIGHT OR FOREIGN MATTER IN THE JOURNALS.—In this case the journals will heat greatly, and the procedure should be as in "Metallic Dust or Foreign Matter in the Bearings," "Imperfect Bearings." The fault may also be due to want of lubrication (see "Defective Lubrication").

D. FRICTION OF THE ARMATURE WITH THE POLE-PIECES. See "Armature Jarring Against the Pole-pieces." The fault is not only shown by reduced speed but by noise.

SYNOPSIS.

Having described the principal causes of the irregular working of a dynamo, it may be useful to tabulate them for purposes of reference. They are as follows:

FAULTS OF FREQUENT OCCURRENCE IN DYNAMO MACHINES.

PART I. THE DYNAMO GIVES NO CURRENT.

A. Remanent magnetism in the field too feeble.
B. Defective contacts.
C. Short-circuit or bad insulation in the internal or external circuits.
  (a) Badly-insulated terminals.
  (b) „ „ brush-holder.
  (c) „ „ armature coils.
  (d) Short-circuit in the armature coils.
  (e) Short-circuit on the commutator.
  (f) Short-circuit at some point of the wiring.
D. Open circuit in the dynamo or external circuit.
  (a) Disconnection in the field coils.
  (b) „ „ internal circuit.
  (c) Brush not making contact.
  (d) Disconnection in the external circuit.
E. Reversed field-magnet coils.

PART II. PRODUCTION OF STRONG SPARKS AT THE BRUSHES.

Causes of serious sparking at the brushes are:

A. Surcharge from the dynamo.
  (a) Excessive voltage.
  (b) Great excess of current.
  (c) Bad insulation of the external circuit.
B. Bad adjustment of the brushes.
C. Bad state of the commutator.
D. Bad state of the brushes or brush-holders.
E. Disconnection in the armature circuit.
F. Short-circuit in the armature.
G. Defective insulation of an armature coil.
H. Weak magnetic field.

PART III. ABNORMAL HEATING IN THE INTERNAL CIRCUIT.

A. Heating of the armature.
  (a) Excessive current in the armature.
  (b) Short-circuit in the winding of the armature.
  (c) Foucault currents in the armature core.
  (d) Humidity in the armature coils.
B. Heating of the field magnets.
  (a) Excess of exciting current.
  (b) Humidity in the field coils.
  (c) Foucault currents in the pole-pieces.
C. Heating of the journals.
  (a) Defective lubrication.
  (b) Metallic dust or foreign matter in the bearings.
  (c) Bent, badly turned or finished shaft.
  (d) Imperfect bearings.
  (e) Drum or shaft making friction with the bearings.
  (f) Belting too tight.
  (g) Armature too near one of the pole-pieces.

PART IV. DYNAMO PRODUCING EXCESSIVE NOISE OR VIBRATIONS WHILE RUNNING.

A. Loose screws.
B. Jarring of the shaft, from the edge of the drum or belting against the bearings.
C. Badly-balanced armature or drum.
D. Armature jarring against the pole-pieces.
E. Joint of the belt jarring on the drum.
F. Humming caused by the teeth of the armature core when passing the pole-pieces.
G. Bad adjustment of the brushes, causing them to grind against the commutator.

PART V. ARMATURE NOT TURNING AT ITS NORMAL SPEED.

A. Surcharge from the dynamo.
B. Short-circuit in the armature.
C. Bearings too tight or foreign matter in the journals.
D. Friction of the armature with the pole-pieces.

It is hardly possible to give fixed rules with regard to all the faults which may occur in a dynamo machine, but it is hoped that the foregoing will be found of some service.

CHARGING STATION FOR AUTOMATIC RAILWAY CARRIAGE LAMPS.

Some years ago (see the *Electrical Engineer* under date of September 6, 1889) we described and illustrated in considerable detail the construction and mechanism of the automatic railway carriage reading lamps devised by Messrs. Davies and Tourtel, who took out patents for the methods and appliances used. Although so long a time has elapsed since they were thus first noticed, the intervening period has been by no means wasted or lost in a tardy development of these lamps on a commercial scale. Many great improvements may be seen to-day in the actual mechanism employed to operate each lamp, and in such practical features as the containing cases, position of light, mode of attachment to the carriage, etc., whilst, in addition, the stages through which the invention has passed have brought into its control men of influence and standing, by whose efforts it is now in active operation on the Metropolitan District Railway. The time cannot, it is thought, be long delayed when it will also be adopted on the Metropolitan Railway, more especially for the Circle trains.

Seeing that we entered with some amount of detail upon the lamp mechanism itself—as already stated—when it was first devised, it is hardly necessary now to again describe it, even although considerable improvements have been effected. Of course, the practical principles involved are the same, and those who wish to see the manner of cutting in or out the light or of rejecting money from the apparatus when defective or exhausted may be referred to our former description.

The arrangements which have been made to recharge the exhausted batteries present, however, some amount of interest, and the following details are therefore given.

In view of substantial developments, and also to adequately cope with existing demands, the owners of this device—the Railway Automatic Electric Light Syndicate, Limited—have erected an admirable charging station at Mill Hill-park, near Acton, and close alongside the District Railway Station, to which there is connection by means of a siding.

The building itself is of brick, and consists of two long sheds or bays roofed over with slate, and having ridge louvres for ventilation where necessary. The whole of one bay is occupied by the charging line and platform.

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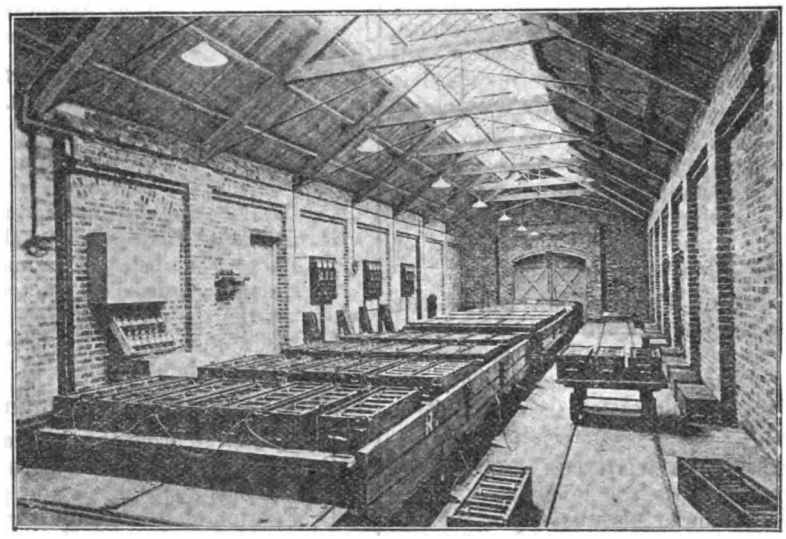
As may be seen from the plan, the siding from the main line runs into the building through large folding doors, and then passes straight up the centre of the bay. On each side are raised wooden platforms, joined at the far end, so as to be continuous, in fact, on the three sides. Down one side runs a small narrow-gauge line of light rails, upon which is placed a trolley for carrying the batteries to and fro.

them quite easily. The separators employed at first were of ebonite ∧ section, but it was found that these were rather apt to flatten out and allow adjacent plates to come into contact. Hence the section was altered to the following ⊓, of rectangular shape, and no more trouble has been experienced on that score.

Each truck is arranged to hold four train sets of seven batteries each, which are charged in series without removal

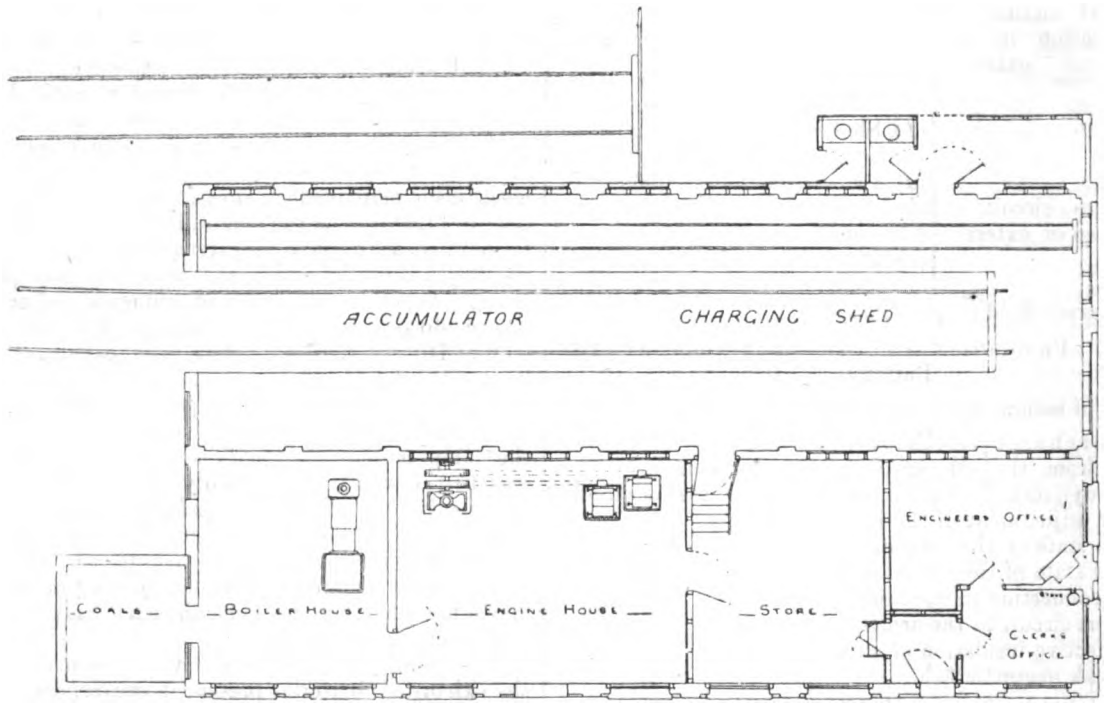


Interior of Charging Shed—Mill Hill Park Station.

The siding has accommodation inside the shed for three flat-topped railway trucks without sides, the ends being arranged to fold down so as to form a continuation of the platform. Some half-dozen such trucks are already in use, and at the time of our visit to the station three, fully loaded with the sets of batteries, were being charged: one, we were told, was at the sub-station at Whitechapel, whence the batteries are distributed to the trains; one was at Lillie Bridge, under similar

from the truck; a simple form of connection being used which enables the batteries to be so rapidly coupled together that the charging can be commenced a few minutes after the trucks enter the shed.

In the trains the batteries are discharged in parallel by means of connections between the carriages; the object being to keep all the batteries in each train set in the same condition of charge, so that, although the batteries from different trains may have reached different stages of



Plan of Charging Station.

circumstances; and the sixth was outside the charging station, snugly covered with a tarpaulin, and ready to go out with a freshly-charged load.

The battery sets themselves contain each six cells of E.P.S. plates specially designed and made for the work, having a capacity of 72 ampere-hours. The containing-boxes are of varnished teak, with handles at each end, and teak lids: their weight is considerable, as may be supposed, but a couple of men are able to manage

exhaustion, upon charging a truck load, all the batteries in each train set will become fully charged simultaneously, and can then be switched off without interfering with other train sets requiring a longer charge—thus economising power. Another great advantage of working the batteries in parallel in the trains is that (owing to the fact that each reading-lamp contains a switch which, upon being operated, is held by an electromagnet during the duration of the light) any temporary break in the circuit,

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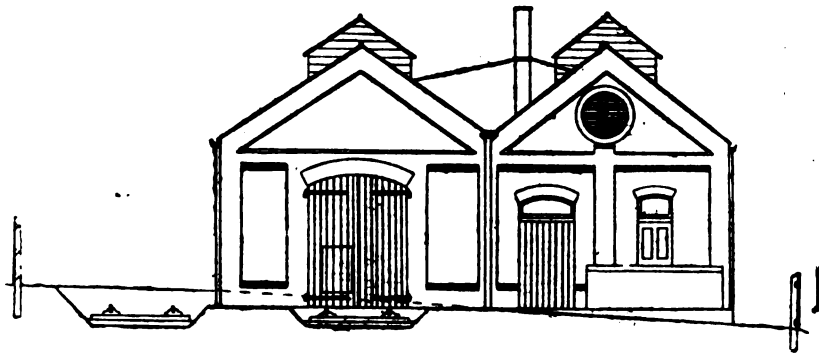
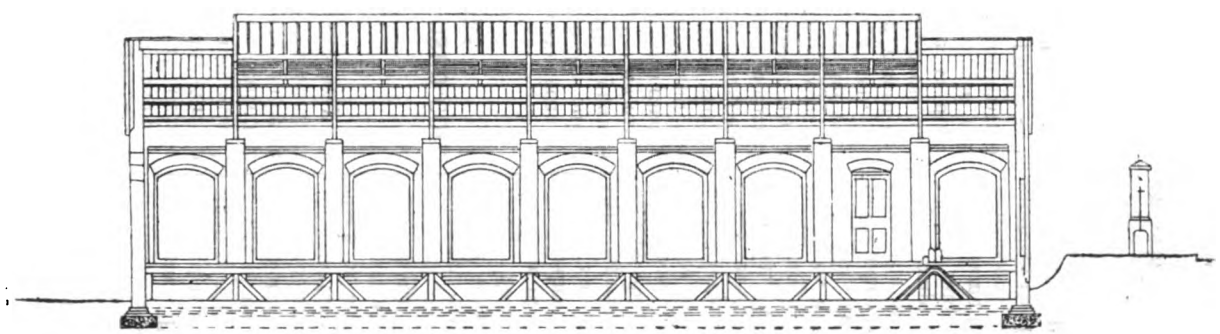
CHARGING STATION FOR AUTOMATIC RAILWAY CARRIAGE LAMPS—MILL HILL PARK.



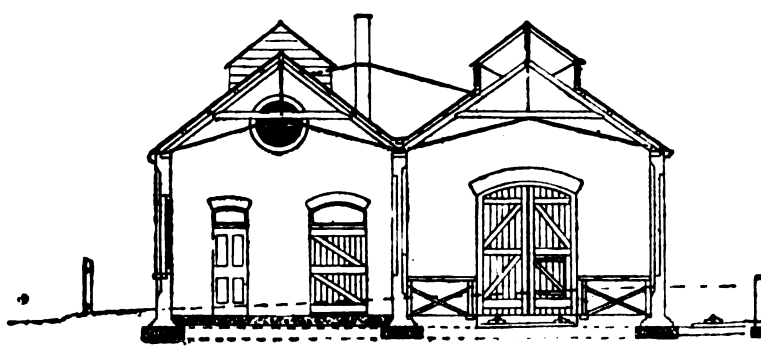
End Elevation from Railway Siding.

Side Elevation from Roadway.

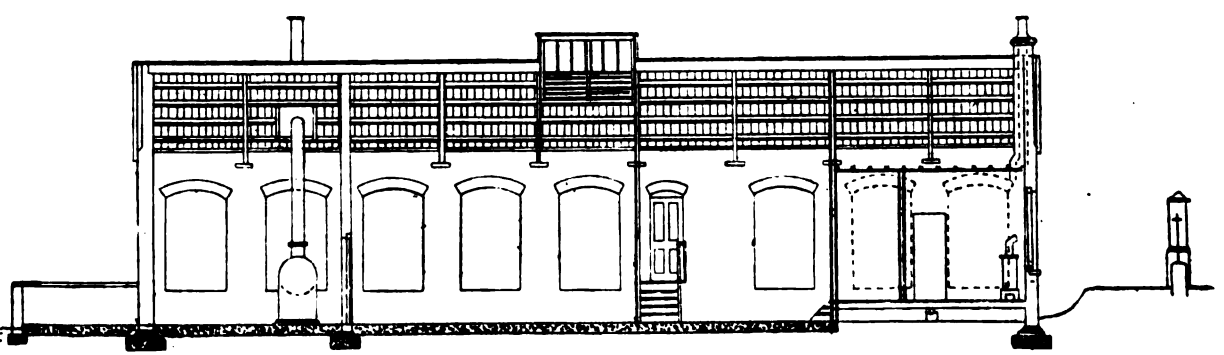
End Elevation from Railway Station Approach.



Longitudinal Section (Vertical) through Charging Shed.



Vertical Cross-Section through Store and Charging Shed.



Longitudinal Section (Vertical) through Boiler House, Engine Room, Store, and Offices.

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such as the fracture of a battery lug, would permanently extinguish the light were it dependent upon a single battery for its supply; but, of course, when the batteries are arranged in parallel, the failure of one, or even several, would not affect the light.

Although the District Railway trains consist of nine coaches, a battery is placed only in each of the second and third-class carriages, because, owing to the lowness of the seats in the first-class carriages, there is no room available.

It is found already, by the way, that the chief receipts from passengers are derived from the second-class carriages, presumably because the first-class are somewhat better lighted than usual by gas, whilst third-class travellers as a rule only take the trains for short distances. Of course we do not now touch in any way upon the whole question of railway carriage lighting, or the advisability of a private outside interest undertaking such work instead of the railway company itself.

The staff required for working the installation of 2,500 lamps on the District Railway is very small: two men stationed at Whitechapel terminus being sufficient for all the battery removals required, as one charge lasts a train from a week to 10 days.

The necessary current for recharging the accumulator sets is obtained from two 10½-unit (100 amperes at 105 volts) Elwell-Parker dynamos driven in parallel by belting from a 30-b.h.p. vertical high-pressure steam-engine made by Messrs. Marshall, Sons, and Co., Limited. The latter is fed from a loco.-type multitubular boiler from the same makers, space being left in the boiler and engine rooms for a duplicate set throughout—boiler, engine, and dynamos. From the generators the current is led to a main switch-board, and thence to three regulating-boards in the adjacent charging-shed—one for each truck on the siding. By this means the current and voltage may be watched and the generating plant properly regulated, and 12 battery sets, of 42 cells each, are charged in parallel at the same time.

Taken as a whole, this station is extremely creditable to its designer; the general plan is convenient, and the details are well worked out. In two words, we should sum up its chief qualities as being "neat" and "substantial." Much credit is due in this connection to the managing engineer, Mr. J. Tourtel, and if the business of the syndicate is carried on with the same thoroughness that characterises its supply station, one would feel obliged to prophesy for it a considerable amount of success.

THE THEORY AND DESIGN OF THE CLOSED-COIL CONSTANT-CURRENT DYNAMO.*

BY HENRY S. CARHART.

Constant-current dynamos for arc lighting have been in practical use for the last 15 years. Most of the public lighting by arc light service has been done with dynamos of the open-coil type. They secured the field at an early day in the development of this branch of electrical industry through the inventive genius of Charles F. Brush and the splendid ability of his business associates. This success was repeated a little later by the equally brilliant achievements of Profs. Thomson and Houston and the phenomenal management of the company formed to exploit their patents. Aside from any question of inferiority, it is therefore easy to see why the closed-coil dynamo for constant currents has remained so long in the background. It has not received the attention to which it is justly entitled, and has not been investigated with the thoroughness and skill which it merits. It is not my purpose to draw any comparisons whatever between open and closed coil armatures. The former is entitled to that consideration which long-continued and satisfactory service in public and private illumination has earned for it. But the latter is making its way into public favour, and it has certain peculiarities which make it an interesting subject for study. If I were to draw attention in this paper to comparisons between dynamos of different types, it would be between those for constant potential and those designed for constant current, both with closed-coil armatures. For in almost every particular the latter is diametrically opposite to the former. The one is designed to give a constant potential; the other a constant current. One is shunt or compound wound; the other series wound. In the one the resistance of the armature is as low as possible in comparison with the field; in the other, the armature resistance is relatively large compared with the field. The one has a sensitive field and is worked below the saturation point; the other should have a staple field, which is worked well up on the saturation part of the curve of magnetisation. Ideally the characteristic of the one is a horizontal line; that of the other a vertical line. In the constant-potential machine the brushes are set only slightly in advance of the theoretical neutral line on plane; in the constant-current dynamo the brushes may be at any point on the commutator according to the load, while the neutral plane remains fixed. When the load decreases with the one, the brushes, if moved at all, are rocked backward for sparkless commutation; when the load decreases with the other, the brushes are rocked forward for minimum sparking or even sparkless commutation and constancy of current. When the load increases on the one, it governs by an increase of induction from an increasing field; when the load increases on the other, it governs by decreasing the counter E.M.F. in the coils between the brushes and the neutral plane. In the one, armature reaction is purposely reduced to the smallest dimensions; in the other, it is purposely made of considerable dimensions. In these comparisons it is assumed that the speed is constant in both cases. If some of these statements are not self-evident, they will be supported, I hope, by subsequent portions of this paper.

The Neutral Plane Independent of the Plane of Commutation.

By neutral plane is meant a plane passing through the axis of the armature and so situated with reference to the poles of the field magnets that when a coil of the revolving armature is carried across it the E.M.F. generated changes direction. This plane intersects the armature in a straight line, but it may broaden out more or less into a surface of small lateral dimensions.

The plane of commutation is a plane passing through the armature axis and the points of contact of the brushes on the commutator. It is the plane joining the poles of the armature considered as an electromagnet. This latter plane of course shifts with the brushes, since the poles of the armature are the points at which the current enters and leaves the armature, and these are necessarily the points or surfaces of contact of the brushes with the commutator, assuming that the connections from the armature to the commutator run directly out parallel to the shaft. To state the proposition now under discussion in the form of a question, Does the neutral plane shift when the brushes are shifted forward or backward? If we were to make answer from the assumption that the resultant of two impressed magnetisations or magnetomotive forces may be obtained in the same manner as the resultant of two forces by means of the triangle of forces, we should probably conclude that the neutral plane rotates forward with a forward movement of the brushes. But experiment along several different lines shows that this conclusion is in error. If we were to apply to the solution of this problem the principles derived from constant-potential machines, we should be forced to the conclusion that to maintain sparkless commutation at the brushes the lead of the brushes beyond the neutral plane should be constant, since the current remains constant, and, therefore, that any attempt to govern for constant current by rocking the brushes must be attended by destructive sparking, unless at the same time the field is greatly modified. But these conclusions are also erroneous. We must therefore first establish the facts, and then make a theory to fit them.

The fixed position of the neutral plane I have determined on a 10-light machine in two different ways.

First Method.—Four turns of No. 16 silk-covered magnet wire were wound around the armature ring as an exploring coil. One end of this coil was soldered to a copper band or ring fastened on the commutator and insulated from it by several thicknesses of mica. The other end was soldered to a piece of brass let into a fibre

* Paper read before the Franklin Institute, December 26, 1893.

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collar placed around the commutator. One extra brush was fastened to one of the main brush-holders, and rested on the copper band. The other extra brush rested on the fibre collar and could be attached to any point of a circular scale made concentric with the commutator. A twisted cord ran from these two brushes to a telephone at some distance. When the dynamo was running, the movable brush, which rested on the fibre and made contact with the brass strip every revolution, was moved around the circle till a minimum sound was heard in the telephone. The exploring coil was then on the neutral plane at the instant when the brush made contact with the strip. Motion of the brush either way caused the sound to increase in loudness. The position of the exploring coil for minimum sound was found to be about 5deg. in advance of the normal plane intermediate between the pole-pieces; and its position did not change from full load to no load as far as could be detected by this method.

Second Method.—To the brush-holders was attached an insulating ring slotted on the periphery at every 10deg. on a milling machine. It was made as nearly concentric with the commutator as possible. A third brush-holder was placed in the successive slots, and the potential difference between it and one main brush was measured in its several positions. These measurements gave the

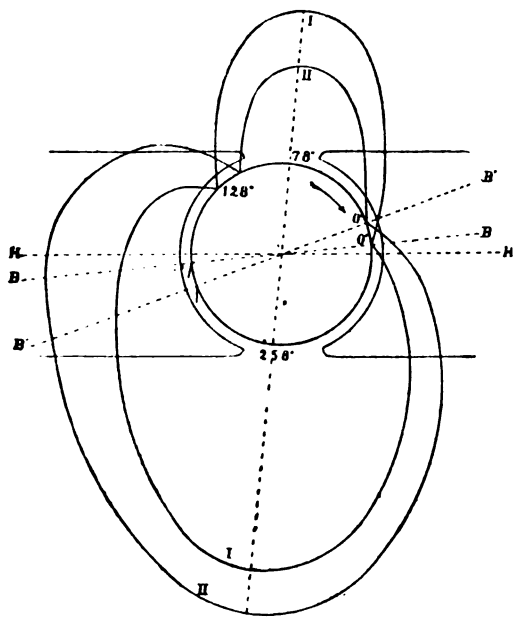

FIG. 1.

integrated potential difference between the main brush and successive points on the commutator all the way around the circle and back to the starting-point. This was done with no load on nearly short-circuit with a load equivalent to three lamps, and finally with a load equivalent to nine lamps—the current being 10 amperes in each case. The results in the first two cases are plotted around a circle in Fig. 1. Positive values, or those in which the potential of the third brush was higher than that of the main positive brush are set off outside the circle in the upper part of the figure, while negative values are set off outside in the lower section of the diagram. The direction of rotation is clockwise. With no load the highest positive potential was about 78deg. behind the positive brush. From this point it fell again, and at 128deg. it was the same as that of the positive brush. For all the coils between 0deg. and 128deg. the integrated positive and negative E.M.F.'s exactly equal each other. The neutral plane falls evidently 78deg. behind the brush, or the brushes may be said to have a lead of 78deg. with no increase in sparking. A negative maximum occurred at about 260deg., and the potential difference between the positive and negative maxima was 644 volts. The same potential difference was found by direct measurement when two extra brushes were set at these points.

With a load equivalent to three lamps the brushes were rocked back 15deg. to bring the current to 10 amperes. Hence the zero of this curve begins 15deg. back from the zero of the first curve. Again the observations are plotted, and the positive maximum falls at the same place on the circle, and, therefore, at the same place on the commutator. The two maximum points are at about 65deg. and 245deg. from the positive brush, and the two potential differences are 168 and 456 volts. Their sum this time is 624 volts, a little less than with no load. With the highest load carried the brushes were rocked backward about 50deg. farther, and the lead was then about 15deg. The extreme potential difference obtainable this time did not exceed 600 volts. So far as can be discovered from these curves, the neutral plane remains fixed, while the brushes move around the commutator to adjust to a constant current. I find no evidence in them that the forward movement of the brushes to control the current causes the neutral plane to move with them. As the brushes advance with a diminishing external load they put between them and the neutral plane an increasing number of armature-turns generating counter E.M.F., and it is a striking fact that when the field coils are not cut out, the back turns on the armature cut down the potential difference between the brushes not by a counter magnetomotive force apparently, but by counter E.M.F.; for the maximum potential difference to be found on the commutator is no less on no load than on full load, showing that at least as many lines of force traverse the armature core with the brushes far forward and with many back armature-turns as with the brushes in the position for maximum load and with the back turns reduced to a minimum.

THREE METHODS OF GOVERNING.

Assuming still practically constant speed, we next enquire into the methods employed to maintain a constant current without appreciable sparking by rocking the brushes around the commutator cylinder.

In one machine the brushes are moved automatically by means of a small electric motor, and at the same time field coils are successively cut out as the brushes rock forward with a light load. A pair of brushes is used on each side, and they are kept at a fixed distance apart. By these combined means the machine can be run on short-circuit with the normal current and without sparking.

Another system leaves the field coils constantly in circuit, but employs two pairs of brushes and varies the angular distance between the members of each pair when the brushes are moved. The movement of the brushes is effected mechanically in response to any change in the main current till the current is brought back to the normal value. In these machines the spread of each pair of brushes, or what is sometimes called the overlap of the brushes, is lessened as they rock toward the polar centres. Very satisfactory results are secured in this way.

In the third class of machines only one pair of brushes is used, which lap over about two or three commutator sections, and the regulation of the current is effected solely by the movement of this one pair without change of overlap and without disturbance of the ampere-turns on the field. The brushes are moved mechanically by means of an automatic regulating device. No less satisfactory results appear to be secured by this method than by the others, while the mechanism as a whole is somewhat simpler.

I have described these three methods for the purpose of pointing out their bearing on the theory and design of closed-coil Gramme rings for constant currents. The important question is not how to get the necessary E.M.F. with such a dynamo, but how to vary that E.M.F. in response to the varying demands of the external circuit, without injurious sparking at the brushes.

The E.M.F. is controlled in all three of these methods by rocking the brushes, and the other differences in the devices are made necessary for the suppression of the sparking. This brings us to a consideration of the most intrinsically interesting topic of the paper—viz., the conditions necessary to suppress sparking and the features of design required to furnish them.

(To be continued.)

Fatal Accident.—Henry Ward, aged thirteen years, while assisting to repair some electric wires at Prescot, near St. Helens, came in contact with an exposed wire, and was instantly killed.

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THE
ELECTRICAL ENGINEER.

Published every Friday.
Price Threepence; Post Free, Threepence Halfpenny.

Editorial and Publishing Offices:
39-140, SALISBURY COURT, FLEET STREET,
LONDON, E.C.

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BLACKPOOL TRAMWAYS.

Blackpool is destined to be a centre of attraction. No doubt its local magnates are not angels, but, on the whole, they are thorough business men, having an ample supply of that North Country commodity which usually results in benefiting Number One. The benefit of the greatest number is a very good election cry, though keen analysis shows that number to be Number One. We have heretofore pointed out that Blackpool is comparatively a small town, yet it is omnivorous in its capacity to attract visitors. It lives upon visitors, it thrives upon visitors, its magnates grow rich upon visitors; hence their great desire not to frighten the goose that lays the golden eggs. At any cost its name must be kept before the seaside-going public. Thus we find it early in testing that which is new and may be attractive. To keep well abreast of the times is a motto never forgotten, and we must say that it pretty consistently manages to take the lead of all rivals. This is as it should be, and such a policy is commendable, so much so, that any tendency to rest and be thankful, or to take retrograde steps, must be deplored and the evil effects pointed out. What does it matter if rents and rates are high provided a commensurate return is obtained? As a financial critic reminds us, why agonise when an expenditure of a hundred pounds never fails to bring a return of a hundred and five? You have only to spend enough hundreds to become rich. Well, that is very much the condition of Blackpool. Again and again of late years in all departments of trade it has been shown that the giving of value for money is never the road to failure. Blackpool must continue to give value, and it will rise still higher than at present in the regard of those whose visits pour into its coffers a perennial stream of gold. How has Blackpool shown its progressiveness, its farsightedness, except in providing for the comfort and the pleasure of its visitors? It has its Winter Gardens, over which genial William Holland presides, as well as other similar attractions; it has its Blackpool tower, which is fast approaching completion and earning power. Then its three piers, and its theatres and music halls, are private adventure concerns, but the town in its corporate capacity has furnished the best-lighted length of parade in the world, and has now in its power to furnish the best tramway of any parade. History tells us that some few years ago an electric tramway was projected and carried out along the Blackpool sea-front, that the system was a conduit one as designed by Mr. Holroyd Smith. Be it remembered Mr. Holroyd Smith's designs were made in very early days of traction work, and of conduit systems especially; that it was therefore a pioneer design, which, although it might possess numerous good points, must necessarily be less perfect than one designed later, when greater experience had been obtained. It is, therefore, not to be wondered at that the troubles of maintenance and celeritous working increased rapidly with age, till they became so great as to cause a return, at least temporarily, to horse traction. Blackpool cannot afford to go back to horse traction per-

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manently, at least if it is desirous of keeping up its reputation; therefore, the candid report of its electrical engineer ought to be welcomed. A careful examination of this report will show the causes of the troubles, and knowing the causes the remedies must, if known, be supplied, or if unknown be sought for. However, they do not seem to be of exceptional difficulty if we put aside that one great bugbear of traction work—the large variation in load. This cannot be effectually combated with ordinary gearing, and we would suggest a consultation with Mr. W. W. Beaumont, who, so far as we can learn, has carefully examined into this question, and designed gearing, described at the last British Association meeting, and in our columns September 22, 1893, which promises good results in practice. It ought not to be difficult to give this gearing a trial, and if found effective in practice, we should at once get rid of the major part of the troubles referred to in this report, such as the breaking of ropes and belts, the breaking of armature connections, and, in fact, all that class of troubles brought about by excessive and irregular strains. With regard to the making of joints and the use of salts as a flux when soldering, such a system ought never to have been passed in the original construction. Mr. Crompton in the very earliest days of electrical work strongly emphasised the uselessness of such joints; but it seems that here, as in other directions, where Mr. Crompton went out of his way to give words of caution his experience had little weight. If joints are made with salts as a flux, they must sooner or later fail and give trouble. It is well that Mr. Hesketh emphasises this as he does in giving the extent of life of such a joint at seven and a half years. The width of the slot is a matter shown by experience to be bad if less than half an inch. On the whole, it seems that the great difficulty is irregularity of strain, and that the working has shown minor faults of design and construction. The authorities should take heart, remedy these evils, and once more put their tramway into the proud position of being the best-equipped and most attractive of tramways owned by corporate bodies in the kingdom.

INSTITUTION OF ELECTRICAL ENGINEERS.

NOTES OF A TRIP TO THE UNITED STATES AND TO CHICAGO, 1893.

BY W. H. PREECE, C.B., F.R.S., PAST-PRESIDENT.

II. TELEPHONES.

(Continued from page 117.)

It should be explained here that the term "trunk" is adopted in America to indicate connections effected between one exchange and another within the same area. Connections between town and town are designated "long-distance" connections. The tendency is to depart from the principle of the multiple switch; and an extremely interesting experiment is being carried out simultaneously in Chicago, Buffalo, and New York to determine the merits of a new system of working called the "divided board." The divided board means this: There are two boards, the one called the answering board and the other the connecting board. The answering board contains the indicators and trunks, including those to the connecting board, and all local connections are treated as trunks through the connecting board. Thus, while each operator at the answering board attends to and answers only her 60 subscribers, and is able still to control all the trunk wires, the local spring jacks are duplicated on the connecting board, which may contain one, two, or three complete sections as the case may be, and are attended to by separate operators. All the business is thus trunked. The result is that the service performed for the subscribers for local connections is slightly retarded. On the other hand, the work done on the trunks is equally expedited. If 50 per cent. of the work done in the central exchange is trunk work, it is argued that if subscribers find that one-half of their work is expedited and the other retarded the expediting of the more important part will compensate for the retardation of the less important, and the general result will be beneficial. The chief merit of the divided board is that it reduces the "jacks," as the switch-holes are called. Seven sections of board with 42,000 jacks would replace 40 sections with 240,000 jacks in an exchange of 6,000 subscribers. I find opinion, however, divided upon this question; but the view is very general that when the multiple switchboard exceeds a capacity of 2,500 subscribers, it certainly introduces disadvantages and defects which must in some way or other be remedied.

Trunk Working.—The trunk working is wonderfully well done. In the first place, the connections between the different exchanges are very numerous. In the central exchange at Chicago there are 344 outgoing and 325 incoming trunks. There are 11 exchanges, and these exchanges are located as nearly as possible in the centres of the districts which they are designed to serve. The business of these offices, however, is by no means self-contained, and a very great amount of their work is in handling calls from subscribers in one exchange to subscribers in another. These are now handled by means of 954 trunk circuits extending between the various offices; the total number outgoing from each office being as follows: Main, 344; North, 34; South, 77; West, 74; Canal, 63; Yards, 61; Oakland, 68; Lake View, 26; Harrison, 59; Wentworth, 19; World's Fair, 80. In Boston, between their central station and Tremont Exchange—an exchange of 833 subscribers—there are 27 outgoing and 33 incoming trunks. The service between two exchanges is virtually a silent one. No question is asked, but instructions are given simply: "301 on North 273." This is spoken on a call circuit. The trunk operator—always a male—wears a headgear telephone, receives this instruction, and carries it out without a word being said, or a second lost. In some places the subscriber, if he wants a subscriber on another exchange, calls his own exchange as usual, and, on getting attention, says "Tremont." He is then placed in connection with the Tremont Exchange, and he himself asks for the number he wants. The former plan is, however, the more general one, and that which is preferred. There are always so many trunk wires available that the operator has rarely to say, "Wires engaged," or "Busy," which is the common expression. I never saw one case of the kind myself. The hourly maximum number of trunk calls between Boston (Main) and Tremont Exchanges was—From Boston, 557; to Boston, 475. The former averaged 20½ per circuit; the latter averaged 14½ per circuit. The result is that in places like Chicago, where there are 11 exchanges, and New York, where there are nine exchanges, the trunk working is done between them virtually as though the whole of the exchanges were centred in one big hall. The long-distance work is done in the same way. Only metallic circuits are switched on to the long-distance lines. The incoming trunk wires end in plugs, the outgoing trunk wires end in "jacks," so that when an operator hears "351 on Chicago 3," he simply takes up 351 plug and puts it in a Chicago jack without hesitation. If, however, all the Chicago jacks are busy—which he sees at once by the visual signal—he says "Busy," and the caller has to wait his turn. In my experience this occurred but rarely. When the calls were heard, the connections were made as rapidly as possible for it to be done, or as rapidly as one could wish that it should be done. In New York the Long-Distance Company and the New York Telephone Company are in the same building. A complete section of the New York multiple board is in the long-distance switch-room, so that connections are made direct between the long-distance lines and the subscribers. Usually a section of the multiple board in the local exchange is allotted for long-distance trunk work to the long-distance office, which may be elsewhere. It is so arranged that when a subscriber talks on a long-distance line his own circuit is entirely cut out from the local operating switchboard. There are a great many public call offices open in every city. There are 535 in New York. They call them "public pay stations." People pay tolls, and they come in and speak to the exchanges and get their connections through.

Long-Distance Working.—The long-distance speaking in the States is very popular and very successful. The opening of the circuit between New York and Chicago—a distance of nearly 1,000 miles—was so successful that they immediately found it necessary to erect two more circuits. There are now, therefore, three circuits between these two places. I tested these circuits, and found the working remarkably good. It was difficult to say

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that it was better or worse than the working of our London-Paris line. The tariff for the long-distance work is based upon one cent per mile for five minutes' talk. The greatest distance that I found upon which speech was conducted was between Milwaukee and Portland, and between these places talking costs 11dol. (44s.) per five minutes.

Rate of Working.—I found that the customers dealt with by each operator varied very much in different towns. The following table will show this :

Town.	Customers per operator — Local.	Long-distance trunk.
Theoretical	100	6
Chicago.....	66	6
Buffalo	100	—*
Boston	70	3
New York, Eighteenth-street.....	50	6
Brooklyn	66	10
New York, Corlandt-street	60	—*

* I did not record the number in these two exchanges.

The daily calls per circuit also vary very much. The average per day over the whole country is 8·03. At Chicago, on one exchange it reaches to as many as 24·3; the mean for the whole town in January was 13·6, while in July it was 12·3. At Buffalo the mean is 6. It is interesting to note that the number at Buffalo is just the same as it was when I visited that place in 1884. At Boston the average number then was 5 ; it is now 12·6. While this average of 12 or 13 calls per day is not an extraordinary one, it represents great extremes in the use of telephones, which bring about complications which are at times difficult to meet. There are in the main exchange at Chicago at the present time several hundred telephones which are used more than 109 times each day. Nearly all this business is handled between the hours of 9 a.m. and 5 p.m. During the busiest hours of the day these instruments are in use almost continually. When calls are made for them, therefore, the only reply is that they are busy. As an example of this excessive use, my attention was called to the case of the Waukesha Hygeia Mineral Springs Company, telephone No. 929 South. A complaint was made by one of their branch offices that they could not reach the main office, the line always being reported to be busy. A record was made of the calls handled on this telephone, and in one day it was found to be used a total of 449 times, there having been 18 originating calls and 431 calls received. In one hour the telephone was used 51 times. This is, perhaps, the busiest line of which there is a a record. Telephones used by railway offices, wholesale houses of all kinds, hotels, and many other places, are apparently in use almost continuously in the busy hours of the day. Many such establishments have more than one telephone, some of them having as many as six. The subscribers per exchange in the exchanges that I visited are as follows : Chicago, 10,312, divided thus : Main, 4,912 ; South, 1,037 ; North, 996 ; West, 903 ; Canal, 434 ; Yards, 392; Oakland, 655 ; Lake View, 244 ; Wentworth, 46 ; World's Fair, 269 ; Harrison, 424. New York : Cortlandt-street, 4,500. Boston : Central, 3,545. The total subscribers in New York are 9,574, at Brooklyn 4,800, and at New Jersey 4,900, making a total for New York and district of 19,274.

Underground Work.—The statistics that I have given show how rapidly underground cables have come into use in the States. At the Chicago central exchange 76 cables, each containing 100 wires, enter the building and ascend up a shoot to the exchange-room. The conductor used is smaller than that adopted by us. It is only No. 19 Brown and Sharpe gauge. It gives 47 ohms resistance per mile, and it has a capacity of 0·68 microfarad per mile. The insulation must be 500 megohms per mile at 60deg. F. All cables before being used are very carefully tested, not only to see that they comply with the specification as to conductivity, capacity, and insulation, but also for what is called "cross-talk," by means of buzzers. There are no less than 14,034 miles of underground wire in New York. One hundred and sixty cables, each containing 100 wires, enter Cortlandt-street building—that is, 16,000 wires enter this exchange. In Boston 91 lead-covered cables enter—that is, 10,920 wires in all, for each cable carrier 120 wires. The cable are made for 50, 60, or 100 pairs of wires. The 50-pair cables have a diameter of 1⅞in., the 60 and 100 pair cables being 2in. and 2¼in. in diameter respectively. These cables are in all cases brought straight to distributing-boards in a room alongside the switchboard-room, and here they are brought to terminals in a way similar to that adopted by us, so that changes can rapidly be made. Subscribers' lines are so distributed among the sections of the switchboards that the work is distributed as uniformly as possible amongst the different operators. The dry-core or paper-insulated cable has proved to be a very great success, and is now universally adopted for telephone purposes.

Chicago.—I have given the number of exchanges and subscribers in Chicago. To provide for this service, there are : Miles of conduit, 48·02 ; miles of duct, or channel, 433·24 ; miles of cable, underground, 106·96 ; miles of wire, underground, 17,995·53 ; number of manholes, 888·0 ; miles of cable, aerial, 65·97 ; miles of wire in aerial cables, 5,184·70 ; total miles of wire in cables, 23,180·23 ; total miles of wire on poles, 7,958·0.

Switchboards and Indicators.—Great improvements in working have been made in consequence of the introduction of metallic circuits. Visual signals, like those employed by the Post Office Department, are coming in. Dirt in the gear was a great source of trouble. False busy signals were frequently received. Now a third wire and an automatic restoring indicator has made the busy test reliable. The visual signals on trunk wires are assimilating the American working to our Post Office system.

Disturbances.—The disturbances in telephone circuits created by the extension of electric railways have been severely felt in many parts of the United States. We have experienced the same in London, Liverpool, Leeds, and Blackpool. But owing to the prompt action taken by the telephone companies, especially in Boston, the area of disturbance has been much reduced, and the influence of electric railways on telephones has ceased to be a trouble. Of course this result is very much favoured by the rapid introduction of metallic circuits into cities ; but it has also been favoured by the prompt action of the railway companies themselves. They did all that they were asked to do, and that at once. In all cases the negative pole of the dynamo at the generating station is put to earth, and the return conductors have been enlarged. Extra copper wires have been buried between the rails, and heavier conductors have been put upon the poles. The return conductor is the largest size copper wire made—viz., No. 0. The rails have been bonded together and to this return conductor ; and in Boston the rails are welded electrically, which is very effective. I was unfortunately unable to see this electric welding in operation, for the transformer had broken down, and was in the shops under repair. I saw the whole apparatus, however. A special car is used for the plant, and the system adopted is extremely satisfactory. The electrolytic action of these disturbing currents has been noticed not only as affecting gas and water pipes, but also the lead coating of the telephone companies' cables. I have seen several specimens of lead pipes much pitted. I have reason to believe that the remedies adopted to cure disturbance will also put a stop to what might have become an element of great danger to underground cables.

Lightning Protection.—A very efficient system of lightning protection has been introduced upon the telephone system, not so much to protect the system from the effects of lightning, as from the effects of those powerful stray currents that enter a telephone circuit when accidental contacts occur between it and electric light and electric railway conductors. Such contacts have been frequent, owing to the prevalence of overhead systems, but they are diminishing now that conductors are placed underground. They have resulted in numerous accidents, and several telegraph and telephone offices have been set on fire and the apparatus destroyed. Every telephone circuit is now protected by a fuse, or cut-out—a fine wire of great resistance, which melts if traversed by a powerful current ; also by an air-space protector on the same principle as the lightning arresters we use, but having carbon plates instead of brass plates ; and, finally, by a small heat coil, which puts the current to earth in a very ingenious way when the stray currents exceed a certain strength. These three guards have been found quite effective. No accident has occurred where they have been used.

Rates.—The rates or rentals demanded from the various subscribers differ very much in the States. At Buffalo they charge a toll rate on each talk ; they do not demand an annual rental ; they simply demand a minimum amount of business per annum. This rate in Buffalo is 10 cents for five minutes' talk, and they have adopted a system of charging one-fifth of this rate for each extra minute beyond the five. The rate in San Francisco is a small annual rental for each installation, and five cents for each talk. A somewhat similar plan is in use at Milwaukee. But, with these three exceptions, the toll system has not found favour in the States, and at every other exchange an annual rental is demanded. The American Bell Telephone Company are now considering the advisability of limiting the time for talks to three minutes instead of five, of reducing the minimum toll in proportion, of making additional charges for each minute *pro rata*, and of considering a fraction of three minutes as equivalent to the whole time. I give, in tabular form, the rentals charged in 25 of the chief cities of the States (Table A).

The rates vary, and are, as will have been seen, very high ; but although the enterprise is in the hands of private companies, it must be noted that they have great difficulties to contend with. In a place like New York the rents and the cost of buildings is excessive. In one small exchange they pay no less than 7,000dol. a year rental for one floor. Taxes everywhere are enormous. Not only are they taxed by the State, but they are taxed by the municipalities. Way-leaves are excessive. In New York alone they have to pay to the

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TABLE A.—STANDARD YEARLY RATES FOR SUBSCRIBERS.

—	Residence.		Business.	
	M'tallic circuit.	Single wires.	Metallic circuit.	Single wires.
	$ $	$ $	$ $	$ $
New York	240	150	180	100
Chicago	175	125	125	100
Philadelphia	160	120	130	100
Brooklyn	150	—	100	—
St. Louis	—	100 120	—	60·80 100
Boston	156 160	120	110 134	96
Baltimore	120 160	78	90 160	78
Cincinnati and Covington	125	100	100	72
San Francisco	*72 90	*60	72 90	60
Cleveland	129	72	100	60
Buffalo	† Toll	—	Toll	—
New Orleans	—	96	—	62·50
Pittsburgh	126	84	112·50	75
Washington	120 160	100	90 160	72
Detroit	—	72	—	50
Milwaukee	‡80 90	60	70 80	50
Newark	150	—	100	—
Minneapolis	120	72	100	60
Jersey City	150	—	100	—
Louisville	—	72	—	60
Kansas City	—	72	—	60
Omaha	—	60	—	60
St. Paul	120	72	100	60
Providence	120	60	100	48

* Also "toll" of five cents per conversation. † Installation charge, 70dol. for first 500 messages. ‡ Rates cover installation and yearly business of 1,000 messages; 10dol. is charged for each additional 500 messages.

NOTE.—Where two rates are given in the same column against an exchange they represent different kinds of instruments furnished. In many cases single-wire rates are no longer quoted for new subscribers.

TABLE B.—CITY POPULATION COMPARED WITH CITY SUBSCRIBERS. COMPARATIVE STATEMENT, JANUARY 1, 1893.

Twenty-four cities.	Population.	Subscribers in exchange.	Average No. of inhabitants to each exchange subscriber.
New York	1,515,301	9,066	167
Chicago	1,099,850	9,684	114
Philadelphia	1,046,964	3,620	289
Brooklyn	806,343	4,439	182
St. Louis	451,770	3,561	127
Boston	448,477	5,668*	79
Baltimore	434,439	2,116	205
Cincinnati and Covington	334,279	4,015	83
San Francisco	298,997	4,528	66
Cleveland	261,353	3,182	82
Buffalo	255,664	2,240	114
New Orleans	242,039	1,471	165
Pittsburgh	238,617	3,254	73
Washington	230,392	1,845	125
Detroit	205,876	4,287	48
Milwaukee	204,468	2,561	80
Newark	181,830	1,094	166
Minneapolis	164,738	2,053	80
Jersey City	163,003	970	166
Louisville	161,129	2,556	63
Kansas City	157,984	2,581	61
Omaha	140,452	1,738	81
St. Paul, Branch of Minneapolis	133,156	1,521	88
Providence	132,146	2,948	45

* Does not include Express subscribers. With Express, 72 inhabitants.

TABLE C.

—	Population.	Subscribers in exchange.	Average No. of inhabitants to each exchange subscriber.
London	4,263,294	6,700	636·3
Liverpool	513,790	4,500	114·1
Manchester	510,998	2,300	222·1
Glasgow	669,059	3,200	209·0
Edinburgh	264,787	900	294·2
Plymouth	85,610	300	285·3
Birmingham	483,526	1,200	402·9
Leeds	375,540	1,300	288·8
Hull	204,750	400	511·8
Newcastle	192,205	1,300	147·8

company controlling the underground conduits no less than 80,000dol. per annum way-leave—8dol. per renter for way-leave alone. The distances, too, that they have to carry their underground system in New York, in Philadelphia, and in other places are very considerable. They have been forced by municipal action to go underground. In the face of these restrictions no comparison between rentals in New York and those paid in this country can be made. The amount of the average rental in London scarcely exceeds £15 per annum. The average amount of rental throughout the country on our Post Office system is £9. 10s., but in New York subscribers have to pay up to £50 per annum. I have drawn up, with the assistance of the American Bell Telephone Company, a comparative statement showing the ratio between the subscribers and the population in 24 principal cities of the States. The details appear in Table B.

It will be seen how very much these places vary. In Providence, for instance, with a population of 132,146, we find one subscriber to each 45 persons; while in Philadelphia there is one to every 289 only. In 10 of the principal towns of our own country the results are as given in Table C.

The telephone in the United States is essential to the business man, and its price is compared with that of an office boy. Labour in the States is expensive, and an office boy costs more than a telephone subscription. The present generation in America has grown up with the telephone. It has become a factor of business, and absolutely essential to the transaction of that business. Its use has passed its climax; it has reached its normal stage. There is no touting for business; business comes. Every new office must have it. The working is excellent, and they are alive to the necessity of maintaining its efficiency at the very highest point. Education is complete, not only of the staff, but of the customer. The apparatus itself is being perfected. Uniformity of practice is being introduced under the operation of the paternal control at Boston, and the influence of technical education and of technical institutions is being felt everywhere. I find a group of highly-educated, clever young electricians being engaged and encouraged by the telephone companies. New blood is being introduced, and great zeal and activity is shown.

III. THE ELECTRICAL CONGRESS.

Two congresses were held at Chicago—the one, a general one, to which all electricians were invited; and the other, called "The Chamber of Delegates," to which nominees from the different Governments were sent. The latter was the more important of the two, but each secured considerable attention, and they were distinctly great successes. The following extract from an American technical journal very fairly summarises the results:

"*The Chicago Congress.*—The much-talked-of international electrical congress is now a thing of the past. Its records may be briefly summarised by saying that the attendance was good; that it was truly international; that there were just about enough papers; that some good work was done; that the social features were enjoyable; and that, while the general management left much to be desired, the congress itself was a success—not quite as grand a success as we should like to have seen, but, nevertheless, a success. Among the papers read were a few which created unusual interest, and some which will doubtless become standards of reference. The papers and discussions were of such a character that the published volumes of the *Proceedings* will be interesting reading, and will become a book of reference. The foreign attendance was such that the congress became truly an international one. Among the foreign countries represented England took the lead in numbers, and especially in papers read, and in the discussions. Germany and France came next. That it was an international assembly was shown by the fact that the French language was freely used in papers and discussions, the only reason why German was not used being that educated natives of that country almost always understand and speak English. Thanks to a few energetic, experienced, and willing members and exhibitors, the social features were not entirely omitted. The social events that did take place were enjoyable, and will be long remembered by those who took part."

The congress met on August 21, at least 500 being present. Prof. von Helmholtz was appointed hon. president; Prof. Elisha Gray, chairman. Each principal European country had a vice-president, and I had the honour of being selected to represent England. The congress was divided into three sections: (*a*) pure theory; (*b*) theory and practice; (*c*) pure practice. Some excellent papers were read, and good discussions ensued. The most prominent subjects dealt with were the transmission of power to great distances, and general preference was shown for alternating-current systems. The work being done at Niagara excited general interest, and some of us visited these works afterwards, with great profit and pleasure. Prof. Ayrton read a very able paper on the variation of arc lamps, so much used in America; while much interest was created by the reading of a paper by Prof. Silvanus Thompson on "Ocean Telephony," a possibility in the future. My paper on "Signalling Through

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Space" also created much interest. Perhaps the most useful result of the congress was the bringing together of such an international mixture of electricians, making friendships, allaying jealousies, and breaking down national prejudices. Electricity is the only branch of science which has but one language, and it is now quite cosmical in its character. Congresses do infinite good in promoting friendliness among nations.

Chamber of Delegates.—The object of this meeting was really to consummate the work done by the British Association and by the Board of Trade, and to secure the official sanction of the United States Government to the units selected and adopted in England. This was done, and the report of the Chamber gives international support to the proposed legalisation of the ohm, volt, farad, ampere, watt, and joule, as defined by the committee of the Board of Trade. There is no doubt that all European Governments will now accept these decisions. A new unit was adopted—viz., the "henry," a unit of induction, which was sometimes called the "quadrant," as defined in Paris in 1889, and sometimes the "secohm," as proposed in England. The acceptance of the name "henry" pleased the Americans very much, for their nationality has hitherto been unrepresented among the celebrated electricians whose names have been applied to the standards of electrical measurements. Germany, Italy, France, were represented by Ohm, Volta, Coulomb, and Ampère; while England absorbed no less than three—viz., Faraday, Watt, and Joule. America has now her Henry, and is satisfied.

The following is the official report of the proceedings: "*Resolved*,—That the several Governments represented by the delegates of this International Congress of Electricians be, and they are hereby, recommended to formally adopt as legal units of electrical measure the following: As a unit of resistance, the *international ohm*, which is based upon the ohm equal to 10^9 units of resistance of the C.G.S. system of electromagnetic units, and is represented by the resistance offered to an unvarying electric current by a column of mercury at the temperature of melting ice 14·4521 grammes in mass, of a constant cross-sectional area, and of the length of 106·3 centimetres. As a unit of current, the *international ampere*, which is one-tenth of the unit of current of the C.G.S. system of electromagnetic units, and which is represented sufficiently well for practical use by the unvarying current which, when passed through a solution of nitrate of silver in water, and in accordance with accompanying specifications, deposits silver at the rate of 0·001118 of a gramme per second. As a unit of E.M.F., the *international volt*, which is the E.M.F. that, steadily applied to a conductor whose resistance is one international ohm, will produce a current of one international ampere, and which is represented sufficiently well for practical use by $\frac{1000}{1434}$ of the E.M.F. between the poles or electrodes of the voltaic cell known as Clark's cell at a temperature of 15deg. C., and prepared in the manner described in the accompanying specification. As a unity of quantity, the *international coulomb*, which is the quantity of electricity transferred by a current of one international ampere in one second. As a unit of capacity, the *international farad*, which is the capacity of a condenser charged to a potential of one international volt by one international coulomb of electricity. As a unit of work, the *joule*, which is equal to 10^7 units of work in the C.G.S. system, and which is represented sufficiently well for practical use by the energy expended in one second by an international ampere in an international ohm. As a unit of power, the *watt*, which is equal to 10^7 units of power in the C.G.S. system, and which is represented sufficiently well for practical use by the work done at the rate of one joule per second. As the unit of induction, the *henry*, which is the induction in a circuit when the E.M.F. induced in this circuit is one international volt, while the inducing current varies at the rate of one ampere per second. The Chamber also voted that it was not wise to adopt or recommend a standard of light at the present time."

An attempt was made to introduce other units, but the feeling is pretty strong that language-framing electricians must rest on their oars for a time. New ideas and new measurements must have new terms and new names, but the general public must become more accustomed to the new language already invented before proceeding to manufacture more novelties in phraseology. The new terms are even now very difficult to explain, and still more difficult to understand. Moreover, electricians themselves are not sufficiently unanimous either as to the necessity or upon the accuracy of the definitions of the new conditions, and therefore they can afford to wait for a final settlement for another congress some years hence—perhaps in Paris in 1900.

IV. The Exhibition.

Nothing grander in design or more beautiful in execution has ever been seen in this world than the group of buildings situated in Jackson Park, Chicago, and called the "World's Fair." It is a great misfortune that the world did not appreciate, nor respond to, the ambitious views of the conveners of this fair. Their conception was magnificent. Their architects, if they did not originate the plans, certainly rose to the occasion. Their builders realised their views. Every possible convenience and accommodation was provided for exhibitors, but the response was poor, and the internal management of the whole business, owing to inexperience and perhaps overweening confidence, was indifferent. The success of the undertaking hovered for some time over failure; but fine weather, patriotism, novelty, real beauty, and cheap fares at last attracted crowds, which, numbering about 200,000 a day, have converted what looked like a disaster into a well-deserved success. I have not much to say of the exhibition as an exhibition. It was very like its predecessors. It did not attract me, for, having taken part in nearly every exhibition for the last 15 years, I am sick of exhibitions. I devoted much attention to the electricity building, and observed there several novelties, some of which I have referred to in other parts of this report. Gray's telautograph attracted much attention. It is an improvement on Cowper's writing telegraph. It reproduces the motion of a pen, so that while you are writing in London a phantom hand seems to guide the pen and reproduce your own writing in Nottingham. You can see the pen move, dot the i's, and cross the t's. It makes corrections and erasures. It works well, but very weirdly. My writing and signature were clearly reproduced at the very first trial. But it is immature for practical trial at present. It has not reached its final stage. It is being improved every day. It is very complicated in construction, and it requires four wires to work it. The Western Union Company in Chicago have established a circuit between their head office and stores department, and are giving it a good test. The French and German Administrations sent admirable and extensive displays of their historical and working apparatus, with a very large staff of men to attend to them, but I am pleased to say that our exhibit proved much more attractive and interesting. It was better arranged and more complete; and our one solitary assistant, Mr. J. Chapman, won golden opinions by the admirable way in which he attended to his duties, and by the excellent verbal explanations he gave of our show. The United States of America made no historic exhibit, but the Western Union Company showed many relics and examples of Morse's early work. The American public were surprised to find how much we in England had anticipated their work. Morse's first message, "What has God wrought?" was sent only in 1844. Our history commenced in 1837. Our jubilee was celebrated in 1887. Theirs is to be celebrated this year. An exhibit that attracted much attention was a door which opened before you as you approached it, and closed behind you as you receded from it. This was done by a small electric motor which was set in motion when you stepped on a mat, and released when you passed through the door. It was worked with the same current that would light an incandescent lamp. Both on entering the harbour of New York, and on going by steamer from Chicago to the World's Fair, channels for the passage of the steamship were clearly marked out at night by incandescent lamps fixed on spar buoys, and lighted up in series. There was shown an electric selector of great merit and some originality. It was a plan by which any particular railway station could be selected and called, any particular signal cleared or put to danger, any office on a long circuit with several intermediate instruments selected and secured, any subscriber on a combination telephone circuit—that is, on a single circuit upon which several renters are fixed—could be called and isolated from the rest. All the great manufacturers in the United States made large exhibits of their wares. The American Bell Telephone Company, the Western Electric Manufacturing Company, the General Electric Company, the Westinghouse Company, and the Standard Electric Company had splendid shows but few novelties. Their novelties have already been referred to, either under electric lighting or electric railway. Electric lifts were on exhibition and in use. They worked very well, indeed, and are rapidly coming into general use in the States. The new postal telegraph building in New York is being fitted with several of these lifts, which are going to be worked very quickly indeed (600ft. a minute). They are being installed by the Sprague Company. Electric welding was shown in full operation, and attracted much attention. Power was transmitted all over the place by currents, and whole exhibits were shown in motion by means of electric motors. Along the machinery hall, 1,400ft. in length, an electric crane, 75ft. span, travelled, and formed an admirable point of observation for those who were allowed to travel on it. It was used in the preparation of the exhibition to lift and fix all the machinery. It lifts and moves 40 tons. It is worked by five motors. Its weight is 58 tons, and its speed was excellent. There were large exhibits of every class of cable manufactured in the States—Waring, okonite, kerite, Patterson, dry-core, etc.; and Felten and Guilleaume had in the German section a fine show of their own make. Sections of streets were shown, with pavement, manhole, conduits, joints, and everything complete. England is the home of the alternator, but it has now taken firm root in America. In 1884 there was not a single one to be found in Philadelphia. Now they are everywhere, and alternate currents are being studied and developed in a way

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that is completely putting our experimentalists in the back row.

The paucity of real novelties, or of what are commonly known as "Yankee notions," was very marked. The necessity for such things—that is, the scarcity of labour—has apparently disappeared, and with its parent the child has languished. Moore's spark interrupter—an automatic vibrating armature in a vacuum tube, by which incandescent lamps can be turned up or down without wasting energy—was described at a meeting of the electrical engineers at New York, but I did not see it at the World's Fair. The distinguishing feature of the Chicago World's Fair was not alone its uniqueness, but its grandeur and its magnificence. It was not an exhibition of goods and manufactures in the Old World sense. No one seemed to care two straws for the mere trade exhibition *per se*; he admired the beautiful buildings, the waterways, the external attractions, and, above all, the congeries of people that assembled from all quarters of that great continent in such multitudes. The distinguishing feature of American engineering is the great scale on which it is carried out, and the rapidity of its adoption. An electric railway from Chicago to St. Louis, 250 miles long, is not a difficult engineering feat, for the country is level, but it is novel for the fact that it is projected to travel at the rate of 100 miles an hour. There were some things in the exhibition that were extremely interesting. The first was a complete reproduction of an ancient Viking's warship—an open boat, that would excite fear and trembling even in crossing the Channel, but of a type that probably crossed the Atlantic long before the famous fleet of Columbus. These vessels—the "Santa Maria," "Pinta," and "Nina"—were also reproduced in all their dimensions, and in all their colours and fittings. The contrast between these relics of the past and the modern warship built alongside the home of the British Commission, Victoria House, was, to my mind, more suggestive than all the innumerable wares and appliances so freely exposed in the vast extent of covered area. One interesting building was a kind of baby cloakroom, where mothers could book their babies for the day, and who were there carefully tended, nursed, amused, and fed for a very small charge. Each mother received a small brass check, which was her guarantee for the safe custody of her little beauty.

V. Electric Lighting.

Electric lighting has not generally made the rapid progress during the past nine years in the States that was expected from its great rate of growth during the previous four years. Wild speculation, hasty construction, fatal accidents, and frequent failures have reacted on steady progress. At the same time the advance has been very great, principally in public street lighting. All towns and villages in all parts of the country, however small and isolated, or however distant, seem to have adopted public arc lighting. Arc lamps are found suspended over the roadways in a very rough-and-ready way, sometimes from stretched wires, sometimes from long-balanced levers, but always effective. The arc lamp-posts are generally of timber, like telegraph poles; occasionally squared timber, as in Broadway, New York; and sometimes plain and neat iron poles, made of differing sections of iron pipes, but rarely so heavy, massive, artistic, and expensive, as in England. Clear glass globes appear to be almost universal in use. It is quite rare to see frosted glass or opaline shades. The principal novelty introduced has been the use of flat carbons or oval or elliptic section, to increase the duration of the light. They are 310mm. long; the major axis is 25mm., and the minor 11mm. The ordinary arc lamps burns as a rule only eight hours, but this flat carbon doubles its life. Moreover, the flat carbon is found very advantageous and useful with alternating-current systems, on which arc lamps as a rule work badly. The standard current used is 10 amperes, and the energy expended varies from 400 to 500 watts. The lamps burn very steadily as a rule, and give a light of about 800 candles at the angle of maximum intensity. An excellent self-regulating alternator for public arc lighting, designed by Stanley, was exhibited by the Westinghouse Company. It maintained its current quite constant, however much the number of the lamps was varied, between 0 and 24. Any number could be turned on or off without the least difference being detected in the current on the light. The favourite arc dynamo in the States is said to be that supplied by the Standard Electric Light Company. There was a large exhibit—six machines—of this type in the exhibition. The largest size worked with 6,550 volts, and maintained 120 arcs in series. It is fitted with a very effective and rapid working automatic governor, regulating the range of the brushes, so that as lamps were turned off the current was maintained constant and the voltage changed. Six seconds only were needed to regulate the brushes from a load of one lamp to 50 lamps. Arc lighting is used very much for shop-lighting, not only in the interior for general illumination, but for advertising and attractive purposes outside. Indeed, many of the streets of the principal cities—especially New York and Chicago—are more brilliantly lighted by the shopkeepers than by the municipalities. In fact, in many cities there are many more arcs supplied for private than for public purposes.

Incandescent Lighting.—Incandescent lamps are, within my observation, invariably used in telegraph offices, post offices, telephone exchange rooms, hotels, and in many railway stations. The electric light is more general in such public places than with us. I did not visit a single place that was not so fitted, and with incandescent lamps. In private houses it is much used, but not so generally as with us. In Chicago the residential lighting is only 33 per cent of the total. In all large cities there are immense blocks of buildings fitted with lifts and used as offices. In all cases they were lighted by their own isolated plants. One of the most striking features of a bird's-eye view from some lofty spot of a great city, like New York or Chicago, is the white, fleecy, wool-like jets of vapour that float gracefully away from the top of every large building. They are to be reckoned by the hundred, and every one means steam plant working lifts and electric light. The Western Union Company at New York and Chicago have their own steam plants. When I visited Chicago in 1884 no central electric lighting station had been built, and no current was supplied. Now, a capital of 2,233,000dol. earns an income of 320,000dol. yearly. The incandescent lamps (16 c.p.) fixed are 136,409; arc lamps fixed, 4,376; motors supplied—total horse-power, 3,612; and this is equivalent to 430,000 10-c.p. lamps fixed, or such lamps as we reckon with in England. The maximum load is 50 per cent. of these lamps alight at one time, which accords with our experience in England. The price works out at 7½d. per kilowatt-hour, or supply unit, and this includes the cost of the renewal of the lamp. The cost of production works out at 3½d. per unit. The cost of the production of electric energy in the States differs, therefore, very little from that experienced here. It is steadily on the decrease. As the load increases, as the daily supply lengthens in duration, as the generators increase in size, so will the cost diminish; and how long it will fall no one can predicate. Anyway, it will certainly far exceed in economy the production of gas. The price of lamps to the undertaker—that is, to the electric light company—is 1s. 4d.; the life of the lamp is 600 hours. A 16-c.p. lamp takes 0·45 ampere and 110 volts. It is, therefore, a 50-watt lamp, and a better one than we get at present in England. The screw socket appears to be in universal use. I wish it were so here. There are three central stations in Chicago. A new station is being built alongside the water in Harrison-street with a capacity for utilising 20,000 h.p., where every modern appliance for cheap fuel, automatic feeding, condensing, and economising will be used. The south side central station is worked by natural gas, which is brought in pipes 100 miles long from Indiana. It is very cheap compared with coal. I found in use in Chicago a system of raising the voltage on the feeders when the pressure falls, owing to the increase of load, by switching in motor dynamos. They have given the name of "boosters" to these instruments. A somewhat similar system has been applied at the Midland Railway, Derby. The exhibition and its surroundings were, of course, brilliantly and entirely lighted by electricity.

(To be continued.)

BLACKPOOL.

Report of the electrical engineer to the chairman and members of the Tramway Committee:

Gentlemen,—Agreeably with the instructions given me at the last meeting of the committee, I now beg to hand you a report giving my opinion as to the present condition of and the causes of the recent trouble with the Corporation's electrical tramway plant. I would respectfully point out that this is now placing on record fully, for the first time, the suggestions and reports I have at various times made verbally to the committee.

Engines and Boilers.—These are in good average condition, only the governors requiring renewal. The valves have been adjusted during the past year, and it is my opinion that there are many years' work yet to be got out of these engines.

Belting and Shafting.—The committee will remember that the engines drive on to a countershafting by means of ropes, and from the countershafting to the dynamos by means of two link leather belts. It is in this important connection that trouble has been given frequently. The ropes on one engine have had to be replaced, the old ones being worn out. Before replacing them it was occasionally necessary to stop one engine and start the other when ropes broke. These stoppages were on an average three to five minutes in duration. On September 9, 1892 (the first day on which the Corporation controlled these tramways), the main belt on No. 1 dynamo broke. Since that date to about August, 1893, one or other of the belts have given trouble on an average every 10 days. These did not, however, cause stoppages of the cars, one dynamo being able to do double duty until the necessary repairs were carried out. It was, however, in the early part of September last that the more serious trouble with the belts began, and although on August 24 I reported to the committee that the belts were rotten and running under protest,

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the difficulties were still further accentuated later. It may be well if I here say that had the load on the dynamos been regular, even though heavy, the belts and all the parts would have borne the strain safely. It was owing to the excessive and irregular strains that the troubles arose, and that the care of these belts became a dangerous occupation. The hole in the roof of the engine-room still stands as a testimony to one of the many breakages. This point is further discussed when dealing with the question of the collector and channel.

Dynamos.—The dynamos are in a condition equal to that in which they were handed over to the Corporation, with the exception of the commutator of one machine, which is worn out. No stoppage has been caused by this. Trouble, however, has been experienced owing to the breaking of armature connections. This is due almost entirely to the heavy strains arising from the "short-circuits" and "cut-outs," also discussed under the heading of the collector and channel.

Motors and Gearing.—The motors have run well, with one or two exceptions, considering their condition when handed over to the Corporation. The field-magnet windings have had to be renewed in some cases, and repaired in almost all. In one or two cases wires had been ripped bodily off the framework of the motor by the steel end of the collector rising and catching the motor on a "break away" happening at a narrow part of the channel. When it is remembered that the disconnection of one wire will stop a car, the importance of this is readily seen. The wiring in the cars has given considerable trouble and in most cases has been renewed. The old joints had been made with salts as a flux, and even though the action was slow it was certain, and at the end of seven to 7½ years all the joints so made became useless. This is interesting as giving the life of a badly-made joint, but as an experience on taking over the old company's system it is disheartening.

Centre Channel and Collector.—In discussing the question of the centre channel, I would venture to invite careful attention to its construction, particularly with reference to the cover rails or troughing and insulators with the method of the attachment to the conductor. The cover rails being fixed, it becomes an impossibility to examine the connections and insulators frequently. Nor can the whole of the insulators be cleaned more than once a year, and even on this occasion they cannot be freely handled. The freedom with which dirt enters the channel is well known. In removing it, it is impossible to avoid leaving some amount round the insulators. In the course of a month or two this becomes a serious consideration, and at the end of 12 months the leakage for the first few hours of the day is sufficient to drive 10 to 20 cars. Then the cover rails expand and contract with varying temperatures, supporting chairs in many instances break, and the slot, which should be ½in., diminishes to three-eighths of an inch or even less. It should be borne in mind that through this slot has to pass the current-carrying conductor to the motors, and that this must be well insulated. To make an efficient collector for this system to pass through a ⅜in. slot is impossible. By an efficient collector I mean one that will run a week without causing any trouble in any kind of weather. Our record during the past year has shown days on which as many as 24 to 30 collectors have been sent into the shed for repairs. The evil effects of the narrow channel and bad insulation are not seen alone in the frequent "breaking away" of the collectors, but react seriously into the engine-room. On the occasion of a collector giving way or a "break away" occurring, the whole of the current from both dynamos and the whole of the engine power is called for in a moment. The strain rises in less than half a second from 2 h.p to 3 h.p. driving the car to 75 or 80, all of which is being spent in burning up the collector or channel. The engines may stand it, but the belts break, and if the belts do not break the dynamos suffer. It is my firm conviction that if the channel construction had originally been such as to admit of a wider slot with more perfect insulators and collectors, the trouble we are at present experiencing would never have occurred. And if the committee is desirous of making the present system run, the only manner by which, in my opinion, it can be done, is by attention to these points.

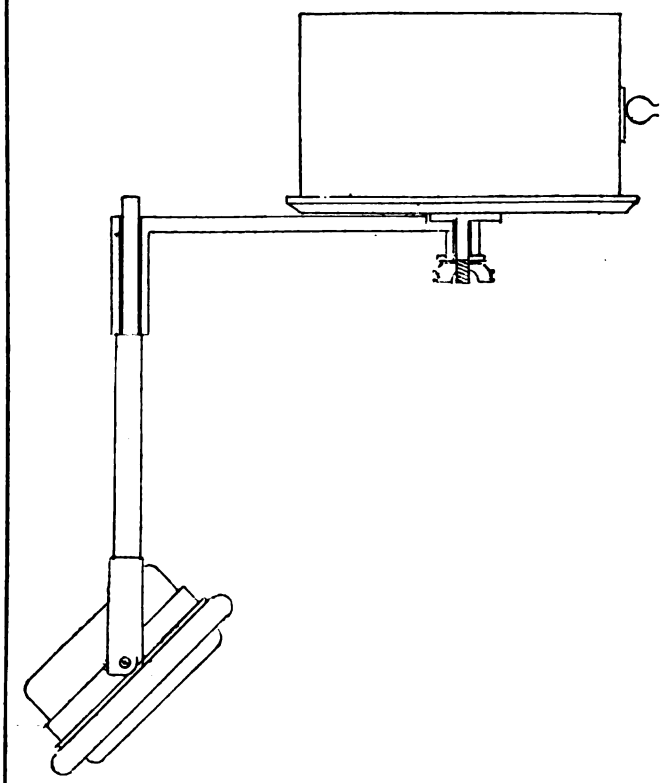
It would not be justice to the staff, who have had to bear the brunt of these troubles, if I did not here record how well they have striven to meet the difficulties as they arose. I am convinced that had not they in my department, and the traffic manager with his staff in his, done their level utmost up to, and more especially since August last, the complaints would have been, if not more frequent, at least more justifiable.

JOHN HESKETH, Borough Electrical Engineer.

P.S.—It is well to point out that if the committee intend to run electrically during the coming season, immediate steps must be taken to put the road in order, and to obtain two new cars.

TELEPHONE RECEIVERS.

Mr. Rickinson has designed a modification of the ordinary rigid telephone receiver holder which he thinks an improvement. No doubt it is often desirable for the listener to have both hands at liberty. Another improvement is the addition of an indiarubber ring to the earpiece of the receiver, termed a pneumatic cushion, its office being to fit closely around the ear and cut off all extraneous sounds, as well as to concentrate the sounds of the telephone itself to the ear for which they are created.



The accompanying illustration shows the arrangement adopted. Besides the joints, as shown, the receiver is swivelled, and can be adjusted for convenience through a short range before being brought up by stops. One advantage of this apparatus is that it keeps the user of the instrument from putting his mouth too close to the transmitter, a position which, added to loud talking, frequently causes indistinct transmission and a rattle in the receiver, which, to say the least, is unpleasant.

COMPANIES' MEETINGS.

CROMPTON AND CO., LIMITED.

An extraordinary general meeting of this Company was held on Tuesday at the Cannon-street Hotel, under the presidency of Viscount Emlyn.

The **Chairman** moved that the directors be authorised to borrow any sum or sums of money upon such terms as they might deem fit, provided that the amount borrowed did not exceed, without the further sanction of a general meeting, £100,000. He said the balance-sheet up to March, 1893, showed that the Company had borrowed from their bankers £18,000. Since that time, with the view of extending their business and taking up contracts, they had found themselves obliged from time to time to increase that amount. The taking up of large contracts meant increased expenditure, and if they could raise an additional £100,000 in debentures, the Company would be in a far stronger position to deal with the business in hand, and that which they felt sure was coming to them. Their object was to displace the existing £50,000 of 5 per cent. debentures to pay off the whole of the bank loans, and to deal with any trade creditors. The debtors of the Company practically represented twice as much as the trade creditors. The issue would only mean an increase of £500 or £600 a year in interest, and this would be more than counterbalanced by the advantages obtained in being able to pay cash for materials, etc. He had no doubt that the directors would be able to raise the whole £100,000 on moderate terms.

Mr. R. E. Crompton seconded the motion.

Mr. Kitchen asked what amount of the Company's assets were represented by shares in other companies; if it was intended to pay the interim dividend on the preference shares in the event of £100,000 being raised; and also if the bank had made any objection to the continuance of the somewhat large loan which the Company had had.

The **Chairman**, in reply, said the shares in other companies amounted to £12,004 in March last, and in September to £12,375. The directors had every hope that they would be able to declare an interim dividend of 2s 6d. a share within a reasonable time, but they could not pledge themselves to any particular date. There was a limit beyond which the bankers would not be willing to let them go, but hitherto they had met them very freely.

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Mr. Kitchen said the directors had first announced that they could pay no more dividend, and then they wanted more money. There might possibly be other reasons for the issue of debentures, and those reasons were what he would venture to call unsound finance. There was a suspicion in the minds of shareholders that the Company was taking large and valuable contracts and accepting a portion of the payment in cash and the remainder in shares. He had seen two companies brought to the verge of bankruptcy by adopting that course, and if this large issue of debentures was to be used in accepting contracts on such terms, he hoped the shareholders would withhold their sanction to the proposed issue. He asked what amount the Company held in the Hove Electric Electric Lighting Company.

The **Chairman** said it was not the case that the directors had announced that they could pay no dividend. What they said was that "Notwithstanding the late serious depression in trade the profits of the Company, during the six months ending September 30 last, were sufficient to justify the directors in declaring an interim dividend; but owing to the necessities of the business in carrying out the various large contracts in hand, the directors had hesitated about doing this until the arrangements for further capital by the present issue of debentures were completed." It had always been his desire that contracts should be made on a business footing—that was to say, that the terms should, as far as possible, be cash, and the directors were now practically carrying out the system suggested by Mr. Kitchen. They had taken £2,000 in shares in the Hove Company really to assist in its formation, and they had a contract at Hove for £35,000, the whole of which was payable in cash. It was with the view of carrying out the contracts in the manner suggested that the directors proposed to issue debentures.

The resolution was then put and carried.

CITY AND SOUTH LONDON RAILWAY COMPANY.

The nineteenth ordinary general meeting was held yesterday (Thursday), at Winchester House, Old Broad-street, E.C., Mr. C. Grey Mott (chairman) presiding.

The **Chairman**, in moving the adoption of the report and accounts, said that he was glad to say that during the past half-year they had again carried the whole of the large number of passengers with absolute safety, and almost with punctuality. As regarded the number of passengers carried, there had been a slight check in the regular increase which the Company had had every half-year. The shareholders would notice from the statement appended to the report that, as compared with the corresponding period of last year, there had been a decrease of 24,251 passengers, but that was exclusive of season-ticket holders. The latter showed an increase of 59, and practically there was an increase on the half-year in the number of passengers carried. The Company would have done better had it not been for special causes. Fine weather morning and evening, as he had pointed out on previous occasions, was always against the traffic on this line, and during the greater part of the half-year exceptionally fine weather prevailed. Then, again, they were confronted with the closing of Kennington Oval for over three months, and the football matches there formed a considerable source of revenue to the Company. Of course, they had lost that traffic, and were continuing to do so for a month or two. When the Oval was again open they hoped to get an improved traffic. The Company had also suffered, in common with other railway companies, from the general depression—not in the same way as if they had goods traffic, but that kind of depression was always felt even on passenger lines solely, and was shown by the large decrease in passenger traffic all over the kingdom. The Company had not been idle during the half-year. The new sidings at Stockwell had been brought into use, and they had been able to give a better service, and decrease the overcrowding in the morning and evening. The result had been an increased mileage of about 10,000 miles more than in the corresponding half of last year. They had also introduced additional intermediate signals, which had also contributed towards improving the service. The Company had been at work at the upper part of King William-street Station, and in the course of the present month that would be finished and opened. It would quite transform the appearance of the station, make it more attractive, and would, it was hoped, tend to increase the traffic on the line It was hoped that the expenditure would be recouped by increased rates that they would get from the left luggage and parcel offices, and other things. A large quantity of debentures came due before the end of the year, and they had paid off some £32,200 of the terminable debentures, and part of those had already been replaced by 4 per cent. debenture stock. The Company had borrowed part of the money to pay them off, but as they are placed on the market that loan would soon be got rid of. The Bill for extensions had passed this session. The chairman then referred to the capital and revenue accounts. With regard to the working expenses, they amounted to 64·6 per cent. as against 67·9 per cent., and if the cost of working the lifts was deducted, came out at about 55 per cent., which was less than most of the railways in the country. The receipts per train mile were exactly the same as last year—namely, 2s. 0½d.; the expenditure 1s. 4d as against 1s. 5½d.; locomotive expenses were 6·22d., as compared with 7·1d. last year, showing a slight reduction. If they deducted the cost of transport of coal, and which other companies had not to pay, the figure would be about 5d. per train mile, which was about half what it cost on the steam lines. Of course the Company's trains were lighter. The receipts per passenger amounted to 1·65d. as against 1·60d., being a slight increase. The question had been raised as to whether the directors should not have taken something further out of the balance brought forward and paid another ⅛ per cent. dividend. Well, the directors thought it would add to the general value of the property of the company that they should show the greatest prudence in this matter, and rather than take from the balance brought forward, they should add a slight amount to it. The line had been open for three years, and he thought they had shown that the electrical system was specially suitable for this class of traffic. He considered it pretty clear now that electricity certainly for metropolitan railways was going to be a cheaper method than that of steam. The position of the Company was very solid. It only needed an increase in the dividends on the ordinary shares to make it rank as one of the first railways in the kingdom. Their securities, preference shares, and debentures, were as solid as anyone could get in these days, and they ought to command as high a price as any railway in the country. The question of carrying out the Islington extension was a matter which they were carefully considering, and were not disposed to move until they were in the position of feeling that there would be no possible diminution of the dividend during the time that the works were being executed But the moment that the extension was carried out and opened, he had not the slightest hesitation that the dividend would advance rapidly. The extra cost of working would be very small, and the receipts would be very large. At the same time they must proceed with the matter with the greatest precaution, and they had therefore not brought any scheme before them on that occasion, and would not do so until they could present a case which he thought they would feel was unanswerable. He then moved the adoption of the report and accounts.

Mr. Edwin Tate had pleasure in seconding the motion.

Some remarks were then made by **Mr. Drake**, who, whilst being thankful for small mercies, said that the management had not made the line a commercial success.

Mr. Blackwood followed, criticising the small dividend and the prospects set forth in the Company's prospectus in regard to a 12 per cent. dividend.

The **Chairman**, in reply, said that it had always been complained that he had always refrained from putting more *couleur de rose* in his statements at the various meetings. The prospectus was issued in the dark as to what the circumstances of the line would be at this time; deductions had simply been withdrawn from existing facts. He did not despair that if the policy they were adopting or intending to adopt was carried out, the day might come when even 12 per cent. might be realised, but it was a difficult operation to perform. Arrangements were proposed in regard to securing some of the traffic passing over London Bridge by the erection of a station on the southern side of the river, and the fares were being judiciously increased. The Chairman then put the motion, which was unanimously adopted.

The dividends recommended were adopted. Messrs Sampson Hanbury and S. Barclay Heward were re-elected directors, and Mr. J. Oliver was reappointed auditor. The passing of a vote of thanks to the directors concluded the proceedings.

ANGLO-AMERICAN TELEGRAPH COMPANY.

The ordinary general meeting of this Company was held last week at Winchester House, Old Broad-street, the Marquis of Tweeddale presiding.

The **Chairman**, in moving the adoption of the report, said that the amount available for dividend was less this year by £13,893. Traffic receipts showed a falling off of £8,493, and this year there was a slight increase in the expenses, amounting to £622. The reduction of receipts was entirely due to dull trade. The failure of the expeditions to repair the two cables had added very much to the wrong side of the account, but the failures were due to the weather. With regard to the condition of the two cables he was glad to say that the 1874 cable was found to be in a good condition, and no doubt it would be easily repairable. The Brest cable, on the other hand, was by no means in the same condition. They had not formed any opinion as to what steps should be taken to put it in a proper condition, but they would have to consult the best of experts upon the matter, and act accordingly Both the Western Union cables were in good order. It was quite necessary that they should be in a position to provide the means of carrying their large traffic efficiently in the future, and after careful consideration they had decided to lay a new cable of a new type, and possessing superior carrying capacity. The cost of the cable would be £450,000, which might be regarded as moderate, being cheaper than any cable laid in the Atlantic, having regard to its carrying power and quality—it would carry about 45 words a minute. The expenditure upon that cable would materially reduce the renewal fund, which, however, it must be borne in mind was established for the purpose of doing what they were going to do. He would have been glad if they could have delayed the laying of the cable for some time, but they had come to the conclusion that it would be imprudent to do so beyond this year. It might be asked how did they intend to fill the void in the renewal fund caused by the large expenditure. He could not give any definite statement as to the life of a cable, and he, therefore, thought the proper mode of dealing with it was to add to the fund each half-year as circumstances permitted. Every half-year they must add a substantial sum to the reserve. He did not think they could be expected to recommend the laying by of a less sum than £40,000 or £50,000, inclusive of the interest on the reserve

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fund, something like £16,000. With regard to the French law-suit, he was glad to say that it would be settled in the course of the next month, at any rate, as far as that particular court was concerned.

Mr. Bevan seconded the motion, which, after some discussion, was adopted, and the dividends having been declared as recommended, the business was concluded.

ST. JAMES'S AND PALL MALL ELECTRIC LIGHT COMPANY.

Directors: Eustace J. A. Balfour, Esq., chairman; H. Woodburn Kirby, Esq., vice-chairman; Gerald W. Balfour, Esq., M.P.; Latimer Clark, Esq., F.R.S.; Sir John H. Morris, K.C.S.I. General manager and secretary, Frederic J. Walker. Chief engineer, S. T. Dobson, A.M.I.C.E., M.I.E.E.

Report of the directors and abstract of accounts for the year ending December 31, 1893.

The directors beg leave to submit their annual report for 1893, the accounts accompanying the same being duly certified by the Company's auditors. These accounts have also been before the Board of Trade. The judgment in the action brought against the Company by Dr. John Hopkinson in connection with the infringement of his three-wire patent was only delivered on January 14, 1893, the day of the issue of the last annual report. The Company, in resisting Dr. Hopkinson's claim, were acting in conjunction with the London low-tension supply companies generally. The directors, after fully considering the effect of this judgment in consultation with their experts, deemed it better to compromise with Dr. Hopkinson rather than run the risk involved in further litigation. They are happy to report that a compromise was effected on very favourable terms, under which the plaintiff waived his costs and granted a license to the Company for the remaining term of the patent and any extension thereof. The cost of the license and the proportion of law expenses attributable to this Company, amounting together to £4,446. 8s. 9d., is considerably less than the additional sum that would have been expended on the mains had the Hopkinson system not been adopted. This expenditure has therefore been carried to capital account. During the year the Company has also been involved in litigation with certain holders of founders' shares, who claimed a moiety of the £2,000 forming the basis of the "redemption fund." This they successfully ligitated, and one-half of the £2,000 has been divided amongst them. The other thousand pounds has been carried to the "ordinary shareholders' undivided profit account." The decision of the Court prohibits the directors from following a policy which all four judges who heard the case approved, and which was directed to conserving the assets of the undertaking for the benefit of the shareholders generally. It is obvious that the ordinary shareholders should not be asked to build up a redemption fund in which it is possible that the founders might ultimately participate to the extent of 25 per cent. under Clause 122 of the articles of association of the Company. An action brought by the Windham Club was settled upon terms satisfactory to the Company. Having regard to the increasing demand for current, and for other reasons, it has been deemed necessary to arrange for an enlargement of the Carnaby-street central station, and in view of this the Company has purchased land on the north and south sides of that station. Plans for this extension are being got out. The directors are considering the issue of debenture stock under the Company's borrowing powers to provide the necessary capital. At the commencement of the year under review, the company which possesses concurrent powers in the parliamentary area allotted to this undertaking started a system of competition which your directors regret to report led to a reduction of price of supply, with a consequent decrease of income. This reduction the directors resisted as long as they could prudently do so, but it became clear in the spring of the year that unless they were prepared to lower the cost of supply they would lose the business that has been built up during the last few years. It is an encouraging feature, however, that the number of the Company's customers has largely increased. From this and other factors working in the Company's interest, the directors believe they may safely hazard the opinion that the diminution of dividend is temporary only, and that in future years the income of the Company will justify a larger return to the shareholders. The coal crisis which has affected so many classes of trade detrimentally has not, your directors are happy to report, affected this Company, for the reason that they had previously secured a contract continuing until the end of March next. They are also pleased to report that the cost of producing the current has not been increased, but, on the contrary, is something below the figures of last year. The shareholders will observe that the securities representing the "capital reserve fund" have been altered. This was done to enable the Company to enjoy a larger rate of interest than they could under the original investment. It will also be noted that although the "redemption fund" no longer exists, the securities representing it have not been sold. The amount is invested in bank stock, which has depreciated, and the directors being of opinion that such depreciation is only temporary, they do not feel it desirable to realise it at existing quotations. The year through which we have last passed has been one which has given your directors much extra work and considerable anxiety. And they have, as in the past, done all in their power to protect and conserve the interests of the Company, and they trust that the fruits of these efforts may show themselves in future years. The net earnings of the Company during the past year have amounted to £10,552. 2s. 7d. Of this sum, £3,500 was distributed in July last in payment of an interim dividend at the rate of 7 per cent. per annum for the half-year ending June 30, 1893, on the preference shares. The balance, £7,052. 2s. 7d., together with the undivided profit of £63. 16s. 2d. from last year's account, and the £1,000 carried from the "redemption fund account" to "ordinary shareholders' undivided profit account" leaves £8,115. 18s. 9d. now to be dealt with. The directors propose to divide this amount as follows:

(A) By payment of a dividend at the rate of 7 per cent. per annum on the preference shares for the second half of the year	£3,500	0	0
(B) By payment of a dividend at the rate of 4½ per cent. per annum for the year on the ordinary shares	4,495	10	0
(C) Amount to be carried forward to "ordinary shareholders' undivided profit account"	115	19	7
(D) Amount to be carried forward to "founders' undivided profit account," per last year's report and accounts	4	9	2
	£8,115	18	9

The question of depreciation is not without its difficulty, but the directors believe that the amount set aside in addition to the expenditure on renewals, repairs, and maintenance is sufficient. The chairman, Mr. Eustace Balfour, and Mr. Latimer Clark, F.R.S., are the directors who retire by rotation under Clause 79 of the articles of association, and, being eligible, offer themselves for re-election. The directors propose to nominate Mr. Bennett Fitch, M.I.C.E, for election as an additional director. The auditors, Messrs. Deloitte, Dever, Griffiths, and Co., also retire, and, being eligible, offer themselves for re-election.

Revenue Account for Year ending Dec. 31, 1893.

A.—To Generation and Distribution of Electricity.

Dr.	£	s.	d.	£	s.	d.
Coal and other fuel, including dues, carriage, etc.	4,379	16	3			
Oil, waste, water, and engine-room stores	701	9	2			
Salaries of engineers and officers	990	9	0			
Wages at generating and distributing stations	2,953	13	5			
Repairs and maintenance as follows:						
1. Buildings £100 10 3						
2. Engines and boilers 620 9 11						
3. Dynamos 162 11 8						
4. Other machinery, instruments and tools 103 18 3						
5. Accumulators 39 3 2						
6. Lamps (at stations) 45 0 8						
	1,071	13	11			
Repairs and maintenance of mains	885	12	10			
Renewals:						
1. Engines 666 14 0						
2. Mains 624 5 11						
	1,290	19	11			
Miscellaneous expenses	63	13	6			
				12,337	8	0
B.—To Rents, Rates, and Taxes.						
Rents payable	194	4	7			
Rates and taxes	887	2	1			
				1,081	6	8
C.—To Management Expenses.						
Directors' remuneration	1,172	9	2			
Salaries of general manager and secretary, engineer, clerks, canvasser, etc.	2,000	13	9			
Stationery, printing, and advertising.	212	17	6			
General establishment charges	230	12	7			
Auditors of Company	78	15	0			
				3,695	8	0
D.—To Law Expenses.						
Law expenses (including provision for costs in the founders shareholders' action)				1,528	1	1
E.—To Special Charges.						
Insurance	157	0	8			
Expenses (other than law charges) in abating nuisances	347	13	10			
Fees for testing meters	1	18	0			
Board of Trade audit	39	2	0			
				545	14	6
F.—To Depreciation.						
Depreciation on buildings	668	19	9			
Depreciation on plant, machinery, etc.	1,292	4	4			
				1,961	4	1
				21,149	2	4
Balance carried to net revenue account				9,910	6	8
				£31,059	9	0

Cr.	£	s.	d.
Sale of current, after deducting provision for bad and doubtful debts	29,389	5	5
Ditto under contract	377	5	4
Rental of meters on consumers' premises	698	11	10
Rents receivable	466	11	5
Transfer fees	41	10	0
Discounts on purchases	70	11	5
Sale of old materials, stores, etc.	13	12	1
Sundry fees, shareholders' lists sold, etc.	2	1	6
	£31,059	9	0

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Dr. GENERAL BALANCE-SHEET, DEC. 31, 1893.	£	s.	d.
Capital account—Amount received	200,000	0	0
Sundry tradesmen and others, due on construction of plant and machinery, fuel, stores, etc.	2,510	3	9
Sundry creditors on open accounts	1,892	16	4
Lloyd's Bank, Limited, temporary loan	15,000	0	0
Unclaimed dividends	5	7	1
Capital reserve fund	15,000	0	0
Net revenue account—			
Balance at credit thereof 10,615 18 9			
Less interim dividend paid on preference shares 3,500 0 0			
7,115 18 9			
Add undivided part of the redemption fund, belonging to ordinary shareholders 1,000 0 0			
For proposed division	8,115	18	9
	£242,524	5	11

Cr.	£	s.	d.
Capital account—Amount expended for works, less depreciation to date	211,029	4	1
Stores on hand :			
Coal 108 12 0			
Lamps 16 13 4			
Meters and switches 768 15 10			
General, including oil, waste, etc. 976 17 4			
	1,870	18	6
Sundry debtors for current supplied 9,091 0 10			
Other debtors 907 13 10			
	9,998	14	8
Cash at bankers (Lloyd's Bank, Limited) 2,515 17 2			
Cash in hand 22 4 8			
Bank of England stock at cost 2,087 6 10			
	4,625	8	8
Capital reserve fund investments—Canada 3 per cent., Cape 3½ per cent., and India 3 per cent. stock, being in substitution of the 2½ per cent. annuities as per last account	15,000	0	0
	£242,524	5	11

The annual general meeting took place on Tuesday at the central station, Carnaby-street, W., under the presidency of Mr. Eustace J. A. Balfour (chairman).

The **Chairman**, in moving the adoption of the report and accounts, said he was anxious to give the shareholders as full information as possible on the various points raised, as well as some facts which bore upon the prospects of the Company for the coming year. It was a matter of regret that it was impossible to pay a dividend of more than 4½ per cent. on the ordinary shares. The following were, however, the chief causes which had led to this result. First, the year had been peculiarly free from fog. The ordinary citizen, when he woke in the morning and found it foggy, did not regard life as pleasant, but the electric light director paid no attention to his personal discomfort, as he realised that the day's earnings of his company would increase by 50 per cent. Another and second cause was the increase in their parish rating by about £570, and the amount they would now have to pay the parish was about equal to 8½ per cent. of the sum available for dividends. The chief cause had been the lowering of their charges forced upon them by competition with the London Electric Supply Corporation. In this connection the chairman referred to a speech made last May by Mr. J. Forbes, chairman of the London Electric Supply Corporation, and who had stated that all the companies had been guilty of folly in competition—unduly rushing down the rates—and that they were all between wind and water. Mr. Balfour was, however, so astonished, that he enquired if the report was correct. The correctness had not been denied, but the statement had not been withdrawn. In justification to themselves he was bound to say that Mr. Forbes was misinformed as to the action of his own company. It was only with great reluctance, and because their customers threatened to go to the London Electric Supply Corporation, that they consented to lower their prices. They disliked this policy, but they had no choice, trusting the time would come when the London Corporation would look at the matter as they did. The fourth cause was the increased economy shown by consumers, especially those on a large scale, some of whom, with the same number of lights wired, had actually diminished their consumption by 25 per cent. There were, however, many satisfactory features in the year's working, which showed that the business of the Company was on a thoroughly sound basis. The number of lamps wired had increased by 25 per cent. At the same time the cost of production had been sensibly diminished, and the directors would endeavour to maintain, and possibly increase, this economy of working. They had been obliged to exceed the estimated capital expenditure by about £11,000. This was due to the necessity of purchasing additional property, and increasing the output of that station by putting down additional boilers and machinery. The remainder was accounted for by the charges in connection with the Hopkinson case. The working of the system was satisfactory, and they had every reason to believe that the customers were satisfied with the light. The Chairman took the opportunity of thanking their staff for the energy and ability with which they had assisted them in carrying on the Company. Mr. Dobson was unfortunately taken ill last July, and, although happily much better, he was still abroad. His place had in the meantime been taken by Messrs. Andrews and Leach, assisted by the secretary.

Mr. Latimer Clark seconded the motion.

The **Chairman**, in reply to questions and criticism of shareholders, said that the cost of management had diminished this year, and he did not think they could find another electric light company in which those costs bore such a very small proportion to the whole cost. With regard to directors' fees, the question was settled three years ago, and the directors then gave an undertaking to which they had adhered. Concerning the litigation over the three-wire system, they were advised by experts on the matter, and it was much cheaper to combine with other companies than to fight it out alone. The second paragraph of the report, to which he referred them, was, he thought a complete justification for the policy pursued by the Company in the matter. They actually gained by defending the action brought against them. In the case of the legal proceedings in regard to the founders' shares, the directors had the strongest opinion of counsel that they would win their case on appeal, and the reasons why they lost that action on appeal were different from those in the first instance. As to further capital expenditure necessary, the reason for that was because they had to purchase property close to the station, and increase the capacity of output. One director had sold 30 shares during the year, and that was the only change. The investments had been changed to obtain a higher rate of interest. The directors had not determined how they were going to raise further capital, but the present proposal was to issue 4 per cent. debenture stock to the shareholders, to be issued only as wanted. The Chairman then put the motion for the adoption of the report and accounts and the declaration of the dividends therein mentioned. The resolution was carried, although not unanimously.

The retiring directors, Mr. Eustace J. A. Balfour and Mr. Latimer Clark, were re-elected, and Mr. B. Fitch was elected a director. The reappointment of the auditors, Messrs. Deloitte, Dever, Griffiths, and Co., concluded the proceedings.

EASTERN TELEGRAPH COMPANY, LIMITED.

The forty-third half-yearly meeting of this Company was held last week at Winchester House, under the presidency of Sir John Pender, M.P.

In moving the adoption of the report and statement of accounts, the **Chairman** said the gross revenue for the past half-year amounted to £369,967, as against £352,301 last year, being an increase of £17,576. There was an increase in the traffic with most of the places they were connected with, the principal being in the traffic with the Cape, India, and beyond. The total ordinary expenses for the half-year had amounted to £98,106, being a decrease of £691 as compared with the corresponding half-year. After paying for the debentures, the directors were able to pay the usual interim dividend for the half-year of 5 per cent., and carry forward the substantial sum of £86,500 to the reserve, the largest amount they had ever carried forward. The Board suggested that an extra remuneration should be given to themselves and to the staff. The directors were working for £1,000 less than they were entitled to by the articles of their association. The chairman expressed his pleasure at the completion of the cable connecting Lisbon with the islands of the Azores and the cable from Zanzibar to Seychelles and Mauritius, under an agreement with the Eastern and South African Telegraph Company. He reminded them of the value of their stock; the 4 per cent. debentures were worth now £116 in the market. They had only been 25 years in existence, and yet they were connected with the whole of the civilised world. He thought their prospects were most satisfactory.

The **Marquis of Tweeddale** seconded the motion, and the report was unanimously adopted.

COMPANIES' REPORTS.

LIVERPOOL OVERHEAD RAILWAY COMPANY.

Directors: Sir Wm. Bower Forwood, J.P.; Jas. Barrow, Esq., J.P.; J. Brancker, Esq., J.P.; H. Brocklebank, Esq., J.P.; R. Hobson, Esq., J.P.; E. Lawrence, Esq., J.P.; Geo. H. Robertson, Esq. Engineers-in-chief: Sir Douglas Fox, M.I.C.E.; J. H. Greathead, Esq., M.I.C.E. Engineer and manager: S. B. Cottrell, Esq., A.M.I.C.E. Secretary: Wm. H. Alexander, Esq.

Report of the directors to be presented to the eleventh ordinary half-yearly general meeting of the shareholders, to be held at the Law Association Rooms, 14, Cook-street, Liverpool, on Tuesday, February 13, 1894.

In presenting the half-yearly statement of the capital and revenue accounts to December 31, 1893, your directors have to report that the gross revenue receipts for the half-year amount to £18,518. 4s. 7d. The number of passengers carried being: First class, 260,221; second class, 1,293,840; workmen (special return tickets), 921,578—total, 2,475,639; making the total number of passengers carried since the opening of the railway, on March 6 last, 3,846,381. The electrical equipment continues to work very satisfactorily. During the past half-year 46,429 trains have been run, and 95·35 per cent. have been punctual. Your directors have taken over from the Electric Construction Company the electrical working of the railway from December 31, 1893, by which they hope to effect a considerable saving in the expenses. Progress with the northern extension was somewhat delayed by the coal

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strike, but the work is now well in hand, and it is expected to be completed about the middle of March. Under the powers sanctioned by the shareholders on August 8 last, £25,000 of the remaining preference capital has been issued and fully subscribed.

Revenue Account.

The gross receipts from traffic amount to	£18,002	16	11
Miscellaneous receipts	515	7	8
	18,518	4	7
Less working expenses	13,732	11	5
	4,785	13	2
From which deduct interest on debentures and on calls paid in advance	2,627	1	10
	2,158	11	4
Add balance brought forward from last half-year ...	3,293	9	0
Leaving available for dividend the sum of	£5,452	0	4

Out of this balance your directors recommend the declaration of dividends at the following rates (less income tax), payable on and after February 16—viz , 5 per cent. per annum on preference shares, £978. 13s. 3d. ; 1 per cent. per annum on ordinary shares, £1,875 ; total. £2,853. 13s. 3d., leaving a balance of £2,598. 7s. 1d. to be carried forward to next half-year. The directors retiring by rotation at this meeting are Mr. James Barrow and Mr. Richard Hobson, who, being eligible, offer themselves for re-election. The auditor retiring by rotation is Mr. George Nicholson, who is also eligible for re-election.

REVENUE ACCOUNT, HALF-YEAR ENDED DECEMBER 31, 1893.

17 weeks ended June 30, 1893. £ s. d.	Expenditure.	£	s.	d.
—	Maintenance of way, works, and stations	1,730	9	10
1,814 3 4	Locomotive power	4,089	17	2
3,197 1 5	Traffic expenses	5,398	10	3
1,116 8 6	General charges	1,375	10	7
56 1 6	Law charges	82	6	0
—	Compensation	1	12	6
771 11 9	Rents, rates, and taxes	1,054	5	1
34 18 8	Sundries.....	—		
6,990 5 2		13,732	11	5
5,361 15 0	Balance carried to net revenue account	4,609	12	8
12,352 0 2		£18,342	4	1

17 weeks ended June 30, 1893.	Receipts.	£	s.	d.
12,085 2 6	Passenger traffic	18,000	11	7
1 17 8	Parcels	2	5	4
253 0 0	Rents	333	14	8
12 0 0	Transfer fees.....	5	12	6
12,352 0 2		£18,342	4	1

Dr. GENERAL BALANCE-SHEET, JUNE 30, 1893.	£	s.	d.
Net revenue account, balance at credit thereof	5,452	0	4
Interest payable or accruing, and provided for	2,552	0	7
Retention money.....	1,675	7	10
Sundry outstanding accounts	5,295	9	0
Renewal fund for boilers and machinery	625	0	0
	£15,599	17	9

Cr.	£	s.	d.
Capital account, balance at debit thereof.....	2,789	10	2
Cash in bank (current account) and in hand	6,258	13	9
Parliamentary deposit on extension railways, authorised by Liverpool Overhead Railway Act, 1892, and interest thereon.....	5,682	11	4
Stock of stores and stationery.....	450	3	6
Sundry oustanding accounts	418	19	0
	£15,599	17	9

The mileage of passenger trains is 243,539, and the amount paid on mileage to the Electric Construction Corporation under the contract for running was £4,058. 19s. 8d.

The Birmingham Cars.—A correspondent has written to a Birmingham paper as follows in connection with the electric cars on the Bristol-road: "With reference to the correspondence appearing in your journal as to the Bristol-road, what is the reason that the Central Company do not grapple with the accumulator difficulty more boldly? Anybody who has seen anything of the traffic upon the road knows perfectly well that what is wanted is a frequent service for the first part of the road, and a less frequent one for the remaining portion, and that the traffic occasionally on the whole of the line is very great. If the tramway company had enough accumulators to work a considerable number of cars in the way suggested they would make a profit, and not, as at present, a loss. To talk about working a three-mile line with three cars seems to anyone, except a director or a resident, an absurdity. It would be interesting to knew the opinion of someone who does understand something about tramway working on such a point."

BUSINESS NOTES.

Western and Brazilian Telegraph Company.—The receipts for the week ended January 23 were £3,445.

Liverpool Overhead Railway.—The traffic receipts of this railway for the week ending January 28 amounted to £632.

Cyfarthfa.—It appears that at the Cyfarthfa Steelworks it is contemplated to have the works illuminated with the electric light.

Cuba Submarine Telegraph Company.—For the half-year just ended the Board recommends a distribution at the rate of 8 per cent. per annum.

Telegraph Wire.—The United Kingdom last year exported telegraph wire and apparatus of the declared value of £1,065,767. The value of such exports in 1892 was £909,917.

Victoria Electric Railway Company.—Letters of allotment for the issue of £100,000 5 per cent. debentures of the Victoria Electric Railway and Lighting Company, Limited, have been posted.

Elmore's French Copper-Depositing Company.—Mr. Justice Wright, on the application of Mr. Buckley, Q.C., on Wednesday, sanctioned a scheme of arrangement which had been arrived at.

Porthcawl.—The Local Board have decided to defer the confirmation of the contract for lighting the streets with gas, in view of a public meeting of ratepayers which was to be held this week.

Kerbey Bowen, Limited.—This Company has been registered with a capital of £20,000 in £10 shares, to adopt an agreement, and to carry on business as ship and boat builders, electricians, engineers, etc.

Birmingham.—Next Tuesday a recommendation is to be submitted to the City Council to adopt a scheme of electrically lighting the Market Hall, at a cost of £1,000 for the necessary lamps, fittings, etc.

Dorking.—The question of providing electrical communication between the police station, the house of the captain of the fire brigade, and the water company's works, is under the consideration of the Local Board.

Froggatt's Electric Lighting Company, Limited.—This Company has been registered with a capital of £3,000 in £1 shares, to enter into an agreement, and to carry on business as electrical engineers, suppliers of electricity, etc.

Marine Steam Turbine Company, Limited.—This Company has been registered with a capital of £25,000 in £50 shares, to enter into an agreement with the Hon. C. A. Parsons, and to carry on business as engineers, shipbuilders, etc.

Kingswood.—Referring last week to the recent visit to Walsall, the chairman of the Local Board said he would like to hear the opinion of the Board in relation to the proposed electric tramway. A unanimous expression of approval was given to the scheme.

Denison Auto-Telegraph Machine Syndicate, Limited.—This Company has been registered with a capital of £1,000 in £50 shares, to purchase the letters patent of the Denison auto-telegraph machine, and to carry on the business of telegraphists and electrical engineers.

City and South London Railway.—The receipts of the Company for the week ending January 28 were £951, against £976 for the same period last year, or a decrease of £25. The total receipts for the first half-year of 1894 show a decrease of £115 compared with those for the corresponding period of 1893.

Messrs. C. A. Parsons and Co.—We are requested to state that by mutual arrangement Mr. A. A. Campbell Swinton has ceased to represent Messrs. C. A. Parsons and Co., and in his place Mr. C. P. Martin has been appointed their London agent. Their London office will continue to be at 66, Victoria-street, Westminster.

St. Saviour's, S.E.—A letter was read at a meeting of the Board last week from the City of London Electric Lighting Company, asking the Board's sanction to the use of their coat-of-arms at their new station on Bankside. It was stated that St. Saviour's had no coat-of-arms, and it was decided to inform the company accordingly.

Newcastle.—Last week, at a meeting of the Town Council, Mr. A. P. Andersen asked the chairman of the Lighting Committee if it was the intention of the committee to keep the present electric lamps in position near the Monument. Mr. Hepburn, in the absence of the chairman of the committee, said the lights mentioned might be regarded as temporary.

Aberdeen.—At a meeting last week of the Gas Committee of Aberdeen Town Council it was stated that Mrs. Stewart, wife of Lord Provost Stewart, would turn on the electric light on February 19 or 20. The meeting had also under consideration the supplying of electric light for the six lamps to be erected in Union-terrace. It was agreed that the lamps should be lighted.

King's Norton.—As mentioned in our last issue, Mr. R. Godfrey, A.M.I.C.E., the engineer and surveyor to the Rural Sanitary Authority, has submitted plans for an extension of the infectious diseases hospital, together with a report on the advisability of introducing the electric light into the whole of the institution. The question of the electric light was deferred for a month.

Sutton.—The clerk to the Local Board last week reported that the draft advertisements and draft specifications for the proposed lighting of the town by electricity had been finally settled by the General Purposes Committee, and that they were now ready for use. He had seen the officials of the Board of Trade as to the draft deed of transfer, and had revised the draft. The draft was referred again to the committee for further consideration.

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Scarborough.—Tenders are invited by the 5th inst. for lighting by electricity the Council-chamber, court house, offices, etc., in the Town Hall, Castle-road, for the Corporation. A specification of the number of lights required may be seen and other information may be obtained at the town clerk's office, Town Hall. Tenders, marked outside "Tender for Electric Lighting," to be sent to Mr. John E. T. Graham, town clerk, Town Hall, Scarborough, by the date mentioned.

India Rubber, Gutta Percha, and Telegraph Works.—Subject to audit, the accounts to December 31 last show the following result: Net profit for 1893, £94,605; brought forward from 1892, £46,845; total, £141,450; less interim dividend, £25,000—£116,450. The directors have resolved to add £50,000 to the reserve fund, and to recommend a further dividend of 5 per cent. (making 10 per cent. for 1893) and a bonus of 2½ per cent., carrying forward £28,950.

Mine-Lighting.—Messrs. William Dixon, Limited, of Blantyre, have placed the contract for the lighting of the workshops, engine-rooms, pit-head, and pit-bottom, at their No. 4 pit, in the hands of the Faraday Electrical Engineering Company, Limited, Glasgow. The lighting is to be done by a single-field Faraday nine-unit dynamo driven by a Robey engine. There will be about 100 lights fitted up, including a number of 50 c.p., and there will be about 50 lamps taken down below to light up the roads, etc.

Aberdeen.—At a meeting of the Education Committee of Robert Gordon's College, the question of the lighting of the college was under consideration. For a considerable time the building has been lighted by electricity, but about nine months ago the dynamo in use was found to be worn out, and a new one was hired. Instead of continuing the hiring of this engine, however, the committee have now resolved to take the current from the mains laid by the Town Council; and at the same time it was agreed that Gray's School of Art should also be lighted in the same way.

Obituary.—An inquest has been held in Birmingham on the body of Henry William Gill, partner in the firm of Ash, Mill, and Co., electricians, Betchworth Works, Birmingham. It was stated that the deceased, who had patented a new electrical process which was being acquired by a London syndicate, remained at the office on Tuesday evening of last week printing letters. He afterwards drank a glass of whisky and water, from the effects of which he died, the water having been taken from a jug which had contained cyanide of potassium. Death was attributed to accident, and a verdict accordingly was returned.

Clacton.—The Local Board have received a communication from Mr. E. J. Gilders, who asked if the Board would entertain a scheme for lighting the town by electricity, or, if they were not prepared to do so, if they would support an application by a syndicate for the requisite powers to make such installation. The Board decided that they were not at present prepared to undertake the cost of an installation, but that they would be willing to support a syndicate on the understanding that the expense of lighting should not be greater than the amount already paid by the Local Board for lighting the streets with gas.

Islington.—At a meeting of the Vestry last week, Mr. Higginbottom called attention to the minutes of the Special Electric Lighting Committee of January 10, upon which were omitted the fact that the committee had enquired as to whether workmen in the employment of the Vestry should be so employed on any of the electric lighting works, and also as to a resolution that was passed. The Clerk said that it was not referred to the committee to report, but only to consider. The resolution passed by the committee was to the effect that the work to be undertaken was of a highly technical character, and the special committee did not deem it advisable that such an experiment should be entered upon.

Keighley.—At the eighth annual meeting of the Keighley Tradesmen's Association the question of electric light was discussed. Complaint was made of the dog-in-the-manger policy pursued by the Corporation, who had not only neglected to place the tradesmen in possession of business facilities enjoyed by smaller towns, but had prevented private enterprise from providing the electric light. The chairman explained what enquiries the Gas Committee of the Corporation were at present pursuing into the subject of electric lighting, and said he believed they would be willing to supply that illuminant whenever there was a sufficient number of prospective customers to make the production reasonably cheap.

Fowler, Lancaster, and Co., Limited.—This Company has been registered with a capital of £50,000 in £10 shares. The objects are to purchase or otherwise acquire and take over as going concerns the businesses carried on Birmingham and elsewhere by Fowler, Lancaster, and Co., Limited, and the Birmingham Telegraph Factory, Limited, to manufacture and let out or hire electric light and power, plant, and fittings, telegraphic and telephonic instruments and appliances, and generally to carry on the business of electrical engineers. The first signatories, with one share each, are: Thomas G. McLauchlan, Charles H. T. Bikker, Edward W. Lancaster, George E. Stembridge, Charles O. R. Pemberton, George M. Fowler, Walter Hands.

Edinburgh.—At a meeting of the Edinburgh and Leith Corporations Gas Commissioners the Works Committee minutes which were submitted contained a report by a sub-committee on the question of "The best means of encouraging the use of gas for industrial and manufacturing purposes," recommending that the Commissioners should allow the remit to drop. Councillor Kinloch Anderson said that the electric light was to compete with them in the way of illumination, and they would lose a great deal in the consumption of gas—in fact, it was estimated that they would lose the majority of their largest customers. If they entered into a system of this kind just now in respect of the amount of consumption of gas, and gave the remaining good customers an increased discount, the revenue would be very much decreased. Therefore it was thought wise at this particular time, and until they saw the effect the electric light would have on the gas industry, to delay taking any action in regard to the motion. The remit was agreed to.

Lighting at Windsor.—The *Windsor Gazette* says: "After vainly struggling to keep the plant going in the interests of the consumers, Messrs. Roger Dawson, Limited, have been compelled to stop running the electric light in the town. Mr. Farrow, their Windsor manager, received instructions to stop running the machinery on Monday. This is entirely due to the bad state of the mains laid down for the electric light company by Messrs. J. E. H. Gordon and Co., which are now practically useless on account of being eaten through in several places by electrolytic action, due to water getting across the two mains, the tar having in many places sunk and left the mains bare. No more light will be supplied until new mains are laid, which will be done at once if the Corporation will only allow the company to proceed. We understand the company have now proved to the Corporation that they are in a position to carry out the work. It would be a good thing for the unemployed if permission were given at once, as the laying down of new mains, building supply station, etc., would find work for 50 men at least for four or five months."

Leicester.—On a motion to attach the seal of the Corporation to a contract by Messrs. Hick, Hargreaves, and Co. for a pair of engines in connection with the electric light installation, Mr. Marshall proposed, at a meeting of the Town Council this week, that no contract be sealed until the members of the Council had received a detailed report from the gas engineer on the tenders from Messrs. Hick, Hargreaves, and Co., and Messrs. Jessop and Son. He said the reason of the amendment was that there was very little difference in the amount of the two tenders, and whilst the tender of the local firm was the lower by £50, the contract was given by the committee to the Bolton firm. He submitted that, on the showing of the engineer, the rejected design was an excellent one, and that if possible the work should be kept in the town. The amendment having been seconded, Alderman Lennard, chairman of the Gas Committee, defended the action of the committee in accepting the higher tender, on the ground that although Messrs. Jessop's was a very good design, the other was, in the opinion of the engineers, a better one, and that the engines agreed upon would be better value than those of the local firm. He, however, was willing to accept the amendment on condition that the report be received from the engineer, and discussed without delay. They were under an undertaking to complete the installation by July next, and if there was a delay of a month in placing the order for the engines it would put them out with the whole undertaking. The motion was ultimately withdrawn, and the amendment agreed to, the report of the engineer to be discussed at a special meeting of the Council.

Easton, Anderson, and Goolden, Limited.—This Company has been registered with a capital of £200,000 in £10 shares (of which 10,000 are 6 per cent. cumulative preferred). The objects are to acquire and take over as a going concern by way of reconstruction the undertaking of Easton and Anderson, Limited (incorporated in 1888), and all or any of the assets and liabilities thereof, and to carry on the business of civil, mechanical, and general engineers, millwrights, shipbuilders, etc. The signatories are Thos. P. Wilson, Frank S. Courtney, J. E. Compton-Bracebridge, Edward W. Anderson, Walter T. Goolden, Llewelyn B. Atkinson, Jas. R. Easton. The new company is an amalgamation of Messrs. Easton and Anderson, the old-established engineering firm, of London and Erith, with Messrs. W. T. Goolden and Co., electrical engineers, Woodfield Works, Harrow-road, London. The former firm, who for so many years have had an extended connection in hydraulic and general engineering work, have more recently been paying attention to the development of electrical transmission. In their Erith works for some four years travelling cranes of 15 and 20 tons have been in work, driven electrically. A special department has been established in their works for the execution of various electrical work. The firm of Goolden and Co. have been prominently before the public in connection with the application of electrical transmission in mines. The nature of the electrical work of each firm being so similar, the combination of the two should lead to an increase of business on either side, as the new company will be in position to carry out in its entirety all the work in connection with a large electrical installation, either for transmission of power and for lighting.

Railway Rates.—The Secretary to the London Chamber of Commerce has issued a circular as follows: "As the railway companies (apparently in concert) are pressing for the payment of the balances of their accounts for 1893, I am instructed to renew the recommendation repeatedly made by this Chamber to its members, not to pay any rates higher, or to accede to any conditions of transport more onerous, than those which were in force in 1892. This action is confirmed by the recommendation of the Select Committee of the House of Commons on Railway Rates and Charges, which states: 'Your committee are of opinion that the margin between the old actual rates and the present parliamentary maxima was not given by Parliament in order that immediate advantage should be taken of it, or that the policy of recoupment should be carried out. Your committee, then, are of opinion that some further steps must be taken to protect traders from unreasonable raising of rates—even within the maximum charges defined by Parliament—and from the imposition of such unreasonable conditions of transport as

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cannot now be made the subject of arbitration. They are of opinion that where, in the case of the raising of a rate, a trader complains that it is excessive or unreasonable, and the conciliation clause fails to result in an amicable settlement between a company and a trader, the petitioner should be at liberty to go before the Railway Commission, and that in such case the Commission should be empowered to decide whether the increase is reasonable or not. In order to meet the cases of the raisings of rates within the present year, which have been the main subject of complaint to your committee, they are of opinion that the power thus proposed to be given should be retrospective to the extent that traders who petition the Board of Trade within a reasonable time in respect of rates increased within the present year should be allowed to go before the Railway Commissioners in the manner recommended. The Chamber will be prepared to lodge, on your behalf, with the Board of Trade a statement of the amounts overcharged by the companies during 1893, and if you are desirous of making use of the Chamber for this purpose, I shall be glad if you will forward such statement at your earliest possible convenience. This need not be in detail, but it will suffice if it indicates the total amount of difference, say, for each separate month, or for as many separate months as it is possible for you to sustain your accounts. It is very desirable that no delay should occur in sending in these statements."

Lighting in the West-end.—The Highways Committee of the London County Council reported on Tuesday that they had considered a notice from the Metropolitan Electric Supply Company of intention to lay mains in Elgin avenue and road, Carlton road and hill, Edgware-road, Portsdown-road, Abercorn-place, Hamilton-terrace, Upper Hamilton-terrace, Abbey road, place, and gardens, Violet-hill, Nugent-terrace, Alma-square, Hill-road, Garden-road, Grove-end-road, Loudoun-road, Elm-tree-road, Circus-road, Hall-road, Melina-place, and Stranraer-place. To these proposed works the committee show no objection, but having regard to their large extent they were of opinion that should any of them not have been commenced within six months of the date of approval a fresh notice should be given in respect of those deferred. They recommended, therefore, that the sanction of the Council be given to the works referred to, on condition that the company give two days' notice to the Council's chief engineer before commencing the works in any thoroughfare referred to; that the mains be enclosed in iron pipes or efficient casing, and be laid under the footways wherever it is found practicable to do so; that as an additional precaution against accident through defective insulation of the mains, each of the street boxes shall be provided with an inner as well as an outer cover, the two insulated from each other as far as practicable, and that the outer cover, which shall consist of an iron frame filled in with material to suit the paving, shall be efficiently connected to earth; that the works be in all respects similar to those approved by the Council on previous notices of the company; and that if from any cause any of the works referred to in the notice be not commenced within six months from the date of the Council's notice of sanction, such sanction shall be held to have expired, and a further notice shall be given by the company and the Council's sanction obtained before such works shall be proceeded with. The committee had also considered a notice from the St. James's and Pall Mall Electric Light Company of intention to lay mains for a short distance on the west side of Regent-street. The proposed works are unobjectionable, and the committee recommended that the Council sanction the works referred to on condition that the company give two days' notice to the Council's engineer before commencing the works; that the covers of the street boxes be supported on 3in. York stone; and that before the street boxes are constructed the designs for, and the proposed positions of them, be submitted to and approved by the Council's chief engineer. The committee had likewise received a notice from the Kensington and Knightsbridge Electric Lighting Company of intention to lay mains in a part of De Vere-gardens. The committee recommended that the Council sanction the works referred to.

Electric Lighting in St. Pancras.—The Finance Committee of the London County Council on Tuesday presented a long report upon an application of the St. Pancras Vestry for £30,000 for 42 years, on the annuity system, for electric lighting purposes. The committee stated that the Council had already sanctioned loans for £10,000 for the purchase of a site, repayable in 50 years, and £60,000 for works, repayable in 42 years. The £10,000 was advanced by the Council, and the £60,000 borrowed elsewhere, as the Council had no power at that time to lend for a longer period than 30 years. This restriction was, however, removed by Section 7 (iv.) of the Money Act of 1892, and the term of 50 years fixed as a maximum limit. On July 25th last they reported on the Vestry's application for a further loan of £30,000, when they recommended (having regard to the amount already borrowed and to certain other circumstances referred to in their report) that the loan should be limited to £15,400. The Council concurred in their recommendation that the repayment of that sum should be spread over 42 years. The Vestry had not taken up this loan, and now renewed their application for the £30,000. The life of the different portions of the work having to be considered, the only satisfactory way of dealing with the present application appeared to be to consider it as part of an application for £90,000, on account of which £60,000 had been sanctioned. It must be borne in mind that an electric light undertaking differed from many other undertakings, in that a very large proportion of the total cost was in respect of works of a short-lived character. The Vestry contended that they should be allowed a longer period than one based upon the life of the work, in order that they might have equal advantages with an electric light company which did not have to pay off its capital, but, even if this be admitted, it must be remembered that a company could not borrow money at 3½ per cent. as the Vestry could, and that a company had to establish a reserve fund to meet depreciation and other contingencies. These considerations led to the conclusion that practically the only safe course for the Council to adopt was to sanction the loan for a term approximating to the life of the work. And there would be this advantage in the course suggested, that the Vestry would be justified in borrowing again for renewals. If the Council accepted this view the present application might be granted as follows: £2,500 for five years, £4,200 for eight years, and £23,000 for 15 years, and in this event the resolutions of July 25 last, agreeing to sanction and lend the Vestry the sum of £15,400, should not be further proceeded with. The committee recommended accordingly. Mr. J. Williams Benn, M.P., moved, as an amendment, "That the recommendation be referred back to the Finance Committee, with an expression of opinion that the total initial cost should be extended over a reasonable period, and without regard to the life of any particular portion of that which forms initial cost, and that the Finance Committee should be at liberty to take such professional advice in addition to that of the officers of the Council as the committee may think fit." Mr. McCall seconded, and, several other members having condemned the recommendation as being prohibitory to electric lighting being taken up by local authorities, the amendment moved was adopted.

The Tramway Question in Leeds.—In the course of an article dealing with the future of the Leeds tramways a local paper says: "In Birmingham the working cost of the cable tramway is 6·18d. per car mile, while that of the electric system in this city is between 5½d. and 6d. This was the rate which Mr. J. E. Winslow, the manager of the Roundhay Park line, gave a representative. But what is the cost of putting down the electric system? Mr. Winslow, who, as engineer for the Thomson-Houston Company, has just completed the electric tramways in Milan, says it would be between £4,000 and £5,000 per mile. Say, £5,000. This would entail an expenditure for the 50 miles of £250,000, as compared with £550,000 for the cable—a difference in favour of the electric of more than one half. The latter would comprise a complete installation, including generating station, well-lighted double-decked cars, and all wires, with the feeder placed underground. Mr. Winslow suggests two sizes of cars—one all covered in, and the other open at the sides on the top. The Thomson-Houston system on Roundhay-road has been very successful so far as the service is concerned. But objection is taken to the overhead wires. An underground system is undoubtedly to be preferred, but, as is obvious, that would entail a much greater expenditure, and it is not certain that it would be as reliable. In a busy city such as Leeds difficulty might be experienced in preventing the slot in the track, through which the car obtains motive power, from getting clogged with dirt, and in maintaining the service when the ground was covered with snow. With the overhead electric system no such risk has been experienced. As for the unsightliness of the wires, it is affirmed by those who live along Roundhay-road that the eye soon becomes accustomed to them, and that the great convenience of the tramway service makes them more than tolerable. There is another important consideration. The establishment of a cable system, even if it were desirable on other grounds, would probably occupy three or four years. Of course, much would depend upon the number of men set to work. On the other hand, it is certain that an electric installation such as we have on Roundhay-road, could be supplied much more expeditiously. Mr. Winslow thinks there would be no difficulty in providing a thoroughly equipped service in 18 months after the lines were handed over to the Corporation. He would at once carry the installation from Sheepscar forward to Briggate. Meanwhile he would proceed with the erection of an electric power station for the whole city, somewhere close to the river where water for the engines could be obtained, and where fuel could be had without cartage. The wires would be laid along the other tracks as fast as they were put into proper order, and in six months the erection of the power station would be so far advanced as to enable cars to be placed upon sections which were then ready. The electric system would give an additional advantage. The thoroughfares traversed could, like the cars, be lighted by electricity, the standards supporting the overhead wires being used for the purpose. Mr. Winslow suggests that the cars should be run 18 hours a day, with a double shift. On the Roundhay-road, in the winter, they start at 20 minutes to 7 a.m., and the last journey is commenced at 11.30 p.m. In summer they commence an hour earlier in the morning. The men are employed 10½ hours to 11 hours per day, the drivers averaging 31s. per week, and the conductors from 24s. to 25s. Last year, says Mr. Winslow, although the line is unconnected with the other tramways, and commences at a considerable distance from the centre of the city, it paid the working expenses. Another interesting fact in connection with the enterprise is that in the first year of running the passengers increased from 700,000 to 800,000." The proposed conditions for letting the tramways have been drawn up, and one portion of these refers specifically to electric traction as follows: "On the determination of the lease the Corporation refuse to be under obligation to purchase any buildings or effects used in connection with or on the tramways; these must therefore be removed. In the case of electric traction, wires under the road must be left for use or disposal of the Corporation without payment to the lessees, unless they can be removed without disturbing the road. The lessees are required to pay by way of security the sum of £10,000, which is to be invested in the joint names of the Corporation and the lessees, the interest to be paid to the lessees; and should there be any breach of regulations the lessees will be liable to a fine of £10 per day during the default,

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and expenses in addition. In the event of the Corporation accepting any offer to lease the tramways, a formal lease containing the above-mentioned and any other conditions deemed necessary will be drawn up and submitted to the Board of Trade for final settlement."

Newport and the Electric Light.—The Electric Lighting Sub-Committee of the Parliamentary Committee of the Newport Corporation on Friday last inspected the high-tension installation which Messrs. Crompton have recently erected at Chelmsford, and afterwards visited another installation provided by the same firm in the Metropolis. Following this, a meeting of the whole committee was held on Monday for the purpose of again considering the question at issue. There was a large attendance, and the whole matter was discussed. As the result of the meeting, we are informed, the committee will adhere to their original recommendation to the Borough Council, which was that the tender of Messrs. Fowler and Co. be accepted. The following comment is taken from a local paper: "It must be said for the Parliamentary Committee of the Newport Borough Council that in connection with the electric lighting of the town they have proved themselves remarkably consistent in their inconsistency, and firm—stubborn is the better word perhaps—when a graceful withdrawal from a false position still remained an easy way out of a serious difficulty. Altogether ignorant of the science of electricity, excusable from their utter lack of experience, they allowed themselves to be far too easily induced to recommend the acceptance of one tender for the construction of the entire works. As they had previously decided that the contract should be given out in about a dozen sections, thereby dividing it between a similar number of firms or companies, this, by itself, was a complete reversal of their original recommendations. The tender they favoured, too, was two or three thousand pounds in excess of the one considered by them as second in point of merit, but regarded as the better one by experts and professional writers of many years' standing. The support given by Mr. Hammond, the borough electrical engineer, to the tender of Messrs. Fowler, was doubtless the one potent factor in securing its recommendation. When the business connections of this gentleman with this particular firm, however, came to be so ruthlessly disclosed, the Parliamentary Committee must have felt equally as strongly as the public has done, that his advice was by no means as disinterested and impartial as his employers had a right to demand. When the Council, as a body, came to consider and discuss the report, they doubtless felt that it was more than possible the committee had been unwittingly led into committing a serious error. If they were not of this opinion, they would scarcely have adopted the step of referring the tenders back to the committee for reconsideration. The committee themselves, for a short time, must have shared in this opinion, inasmuch as at a special meeting they decided, after a most lucid explanation by Mr. Crompton, the tender of whose firm was the second one alluded to, to postpone any further recommendation until they had reconsidered the matter again. Since then Messrs. Crompton, as showing their anxiety for undertakings of a similar nature carried out by them to be personally inspected by the committee, invited this body to Chelmsford to go over one of the firm's latest works, and this has been done. No change, however, is to be effected in the original recommendations. One of three things has happened. The committee perhaps are still completely under the influence of Mr. Hammond, and find themselves with insufficient backbone to make a real effort to rid themselves of the incubus. It may be that they are conscious of the error they have committed, but are determined to stand by it rather than that their supposed prescience and safe judgment shall run the risk of being weakened in the opinion of the ratepayers; and it is just possible that they are honestly convinced that, after all, their original recommendation was a wise one, thus justifying them in abiding by it. At all events they did this at a further special meeting held on Monday. Yet the entire matter is enveloped in so much doubt that the Council will be far more than justified when next they meet in discussing it with perfect freedom, and, if necessary, without paying but little regard to the actual recommendations of the committee. This may appear to be treating the latter body with a certain amount of discourtesy. The issues at stake, however, are so important, and the present amount involved so large, to say nothing of the outlay to follow, that the Council must fearlessly do its duty. What that duty is appears remarkably plain."

Conversazione of the Swindon Junior Engineering Society.—The members of the Junior Engineering Society in connection with the Swindon G.W.R. Mechanics' Institution spent an enjoyable time with their friends at a conversazione in the large hall of the institute on Tuesday of last week. The society, which has been in existence some 15 months, and already boasts of a membership of about 80, receives encouraging support from the leading officials in the works, Mr. W. Dean being president, and the vice-presidents' list containing, in addition to the name of Mr. N. Story-Maskelyne, those of Messrs. S. Carlton, G. J. Churchward, D. E. Marsh, E. C. Riley, W. H. Williams, and W. H. Stanier. There was a very large company at the gathering, and the programme was sufficiently varied to suit the tastes of all. Besides an interesting address by Mr. N. Story-Maskelyne some excellent selections of music were given, while during the latter part of the evening dancing was a great attraction. But without endeavouring to minimise in any way the merit of these forms of enjoyment, it must be said that the exhibition of working models, microscopes, electric lighting appliances of different kinds, etc., was fully as interesting from the point of view of many of the company as well as in the opinion of the students. In the centre of the room was a novel feature in the form of an electric fountain, lighted with incandescent lamps, the design and work of Mr. H. G. Cotsworth. An interesting exhibit by Mr. G. B. Clifton comprised a Willans-Robinson engine. Thanks are especially due to Mr. W. L. Holt, who was untiring in his efforts to get an interesting collection of specimens—efforts which, it is hardly necessary to say, were fully successful. On the stage was a collection of electrical appliance, microscopes, etc. Conspicuous among the latter was a first-class Powell and Lealand microscope, kindly sent by Mr. Story-Maskelyne, and brilliantly illuminated by an electric lamp. During the first half of the evening the stage was lighted by 10 16-c.p. electric lamps worked from a dynamo in the basement, the arrangements for the supply of the current being carried out under the personal supervision of Mr. E. J. Tincknell. Other exhibits comprised Thompson's calorimeter, a specimen of electric welding, a compound cable of steel and iron lent by Mr. Thomas, etc. Some of the most interesting exhibits were those sent by the Lithanode and General Electric Company, London, whose general manager, Mr. J. T. Niblett, was present. Miners' safety lamps were shown in two forms, and were guaranteed to be perfectly safe, even in the most dangerous surroundings. The smaller size, which will run from eight to ten hours, costs only ¼d. for electricity per shift; while in the case of the larger lamp, which lasts from 12 to 14 hours, the cost is about ½d. A lamp was also shown for railway carriage reading, as well as a three-cell hand lamp with fixed lantern. Another interesting exhibit was an 8 c.p. incandescent electric lamp supplied from a six-cell, 30-ampere hour accumulator, and made for the Glasgow Corporation for illuminating their new tramcars; and a five-cell, 18-ampere hour lamp for omnibuses and trams, the connection being established by the driver dropping the battery into the box. Samples of the different plates used in installation, with plates, cells, and all the mechanism of miners' lamps were explained separately. In the course of his address, Mr. Story-Maskelyne said: "How wide is the range of subjects that fall within your ken is evidenced by the programme of your current session. I find discourses on such widely-different subjects as fuel, to which an entire volume of the last technological encyclopædia is devoted to; lubricants, a subject involving important questions as to the mechanics of friction; measurement of temperature, the difficulties of which begin when we pass from the regions covered by our ordinary thermometers to pyrometers, and other modes of estimating very high or very low temperatures; electric measurements and their units; water power, and the various ways of using the potential energy of stored water; the chemistry and metallurgy of copper, that, after iron, most important metal—important for its useful and beautiful alloys and for its conducting power, and also as illustrating the influence of minute amounts of extraneous ingredients in modifying the properties of a metal. Why, gentlemen, here are subjects that all bear on engineering in the most direct manner; and what a vast field does practical engineering now cover: the whole range of mechanics is its own: the several branches of physics, including heat and thermo-dynamics and electricity, are no less within its sphere, and chemistry and metallurgy also bring their tribute to the practical engineer. Of these subjects many need mathematics, are, in fact, unintelligible except to the man who has mastered something of that great language of nature. I need hardly urge on you to seek every opportunity of extending your grasp of mathematical methods. You will hardly aim at announcement of discoveries in science. Your time is, I opine, too fully occupied for the long and laborious investigations which lead to new scientific truths. But a large field of invention is open to you, for this needs thought and originality founded on facts and principles already established. The annals of your society may well be gilded by the record of improvements in methods and apparatus and in machinery suggested to you in your daily contact with engineering problems. The highest order of discovery belongs to men who can give long hours to research. The man of science—the philosopher, as Faraday persistently called him—simply ignores usefulness. His aim is a lofty one—the advance of man in the knowledge of the sublime laws that preserve the order of the universe. Practical results are the by-products of his work, the chips from his workshop. Pick them up where you can; it is yours to utilise them for the daily use of man. But reverence their source! Some arts are older than the sciences that illustrate them; such as agriculture, metallurgy, and many of the domestic arts. But he would be foolish indeed who scoffed at the science that explained the art, and pointed the way to its improvement, even though some of its problems remained still unsolved. Other arts again are born of science. They are its children. Steam, chemical industries, including gas, are so. Electric and electromagnetic science is emphatically the offspring of research, and of the highest mathematical analysis. If the nomenclature of electric science honourably recalls the names of some of the greatest experimentalists of a past fruitful century in the Watt, the Volt, Ohm, Ampère, Faraday, and Coulomb, our own latter half of the Victorian era has its Clerk Maxwell, Helmholtz, Kelvin, Hertz, Fitzgerald, and, let me add, its Larmor, to point to as among the great mathematical thinkers who have made electricity the most important of sciences. And what are the by-products of all this magnificent work? Well, you have the telegraph, the telephone, the electric light, the transfer of energy from place to place by the simple agency of a copper wire. And let me here for a moment detain you to point out another step we may expect soon to see taken. You may first ask me perhaps, What is electricity? Men not long ago asked, What is heat? There were those who thought

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heat was a subtle substance that was passed into or out of the supposed pores of matter, and discussions have been held as to whether there were two or only one electricity. We now not only know that heat is but a form of energy—in fact, a mode of subtle motion—but, thanks to Joule, we are able to assign its equivalent in the work it can cause to be done. We have our heat unit. We have, too, our electric units, yet we are still unable to give a complete answer to this question. What is electricity? To return to my point, I can only here allude to that immortal dream of Clerk Maxwell that, as the ratio of the expressions for the electrostatic to those for the electromagnetic units had the mathematical form of a velocity, the ratio of a distance to a time, and as the velocity so calculated approximated to the velocity of light (183,000 miles in a second), and must be propagated through some sort of dielectric medium corresponding to the ether, therefore light might perhaps be an electromagnetic emanation. A German philosopher, Hertz, who died but three weeks ago on the banks of the Rhine, at Bonn, proved the vision of Clerk Maxwell to be a physical truth. He showed that heat and light are, in fact, identical in character with electromagnetic disturbance in the ether ocean that fills all space and penetrates all matter, a disturbance of the character of waves: such waves he proved to emanate from a wire through which a rapidly-oscillating electric current was being transmitted. They differed from heat and light waves only in their greater length of wave. As the pedal pipes of an organ form one extremity of the long series of octaves at the other end of which are the treble notes, so these waves belong to octaves where the vibrations are profoundly 'bass' (many yards in wave-length), while the luminous rays that we call light comprise barely a single octave somewhere in the higher region of the long gamut of ethereal pulsations, 50,000 of them recurring in a single inch. Why do I dwell on this fascinating theme? Well, for a practical purpose. You are aware that, of this long gamut of pulsation, we already know that quite at the treble end the invisible rays beyond our visual ken are the most effective in producing chemical (photographic) changes, such as bleaching dyes and stimulating plant life. The visual rays perform this function, too, besides having heating properties, while beyond the visible rays in the direction of the bass end of the gamut the heat rays are the most effective. These attributes belong to each single ray, not to different commingled rays. But in order to produce an electric light of any useful intensity, we have to expend an amount of work far beyond what should be necessary to impart to the ether that luminous thrill. This is chiefly expended in producing waves of longer wave-lengths that have no luminous effect for our eyes. The problem, then, is to find the means of producing only the rays we want without this prodigious waste. You will ask, Can it be possible? The answer is, Yes, it must be possible. The firefly on a small scale does it, so does the

'Glow-worm golden in her dell of dew
Scattering unbeholden her aerial hue
Amid the flowers and leaves that screen her from the view.'

This, then, is a practical problem within the sphere of the practical electrical engineer. I put it before you as one of the great economical steps that may be taken in the immediate future, and to which every ingenious and thoughtful mind may be usefully directed, and it serves as an illustration of the main idea that runs through the discourse with which I fear I have wearied some portion at least of my audience who have come here to-night for a different variety of entertainment."

PROVISIONAL PATENTS, 1894.

JANUARY 22.

1320. **Improved electrical insulated fitting.** Charles Cunningham Connor, Notting-hill, Belfast.

1356. **Improvements in electrolysis.** Emile Andreoli, 18, Somerleyton-road, Brixton, London.

1375. **Improvements in rapid telegraphic transmission.** Charles Langdon-Davies, 24, Southampton-buildings, Chancery-lane, London.

JANUARY 23.

1417. **Automatic device for removing resistance in starting electric motors and replacing same.** George Herbert Whittingham, 52, Chancery-lane, London. (Complete specification.)

1433. **Apparatus for advertising by means of electric lamps.** William Falconer King, 154, St. Vincent-street, Glasgow.

440. **Improved electric battery.** John Peel, 8, Quality-court, Chancery-lane, London.

1473. **Improvements in dynamo-electric machines.** Henry Harris Lake, 45, Southampton-buildings, Chancery-lane, London. (George Frederick Dieckmann, United States.) (Complete specification.)

1478. **Improvements in connection with phonographs, grammaphones, graphophones, and similar sound recording and reproducing instruments.** Jonathan Lewis Young, 4, Moorfields, Fore-street, London.

1491. **Improvements in arc lamps.** John Brunswick Barton, Norfolk House, Norfolk-street, Strand, London. (William Jandus (United States.)

1495. **Improvements in commutator brushes.** William Lloyd Wise, 46, Lincoln's-inn-fields, London. (Otto Hering, Germany.)

1479. **Self-acting hydraulic apparatus for winding up mechanisms actuated by weights or springs, such as Hughes telegraphic type-writers, Morse telegraphs, etc.** Robert Howe Gould, 55, Holborn-viaduct, London. (Complete specification.)

JANUARY 24.

1532. **An improved system of metering electric currents.** Ernest George-Pink, 10, Seville-place, Dublin.

1542. **Improvements in or relating to facsimile telegraphy.** Harry William Charles Cox and Richard Joseph Crowley, Harbour-row, Queenstown, Ireland.

1582. **Apparatus and process for converting heat into motive power or electricity (or both) and for cooling and refrigerating.** Frederick Stone, 62, Uttoxeter New-road, Derby.

JANUARY 25.

1605. **Improvements connected with incandescent lamps or burners.** Harry Tee, 15, Water-street, Liverpool.

1657. **A method of and apparatus for communicating electricity to vehicles.** Henry Percy Holt, 28, Southampton-buildings, Chancery-lane, London.

JANUARY 26.

1686. **Improvements in propelling locomotives by electricity and in apparatus therefor.** Rankin Kennedy, 1, Clifton-villas, Camden-square, London.

1698 **Improvements in telephone transmitters.** Richard Steenberg, 3, St. Nicholas-buildings, Newcastle-on-Tyne.

1701. **Improvements in and connected with electric conduits.** Carrington Riddell Gordon Smythe and Archibald Hendry Dunnachie, 154, St. Vincent-street, Glasgow.

1744. **Improvements in electro-deposition.** William Stepney Rawson, Cadby Hall Works, Hammersmith-road, London.

JANUARY 27.

1776. **Improvements in electric arc lamps.** William Aloysius Walton, London-road, Gloucester.

1788. **Improvements in electric glow lamps.** John Pitt Bayly, 18, Fulham-place, Paddington, London. (Wilhelm Wiklund, Sweden.)

1794. **Improvements in electrical traction or electrical railways and tramways.** William Adkins, 6, Livery-street, Birmingham.

1798. **Improvements in electric signalling apparatus, and in apparatus connected therewith.** John William Fletcher, The Homestead, Cale-green, Stockport.

1810. **Improvements in electrical measuring instruments.** Harold Edward Sherwin Holt, Broom Hall Works, Teddington.

1849. **An improved arc lamp.** Frank Taylor, 45, Southampton-buildings, Chancery-lane, London.

SPECIFICATIONS PUBLISHED.

1889.

19153. **Phonographs.** Hardingham. (Edison.) (Third edition.)

1890.

7932. **Mandrels for electrolytically-deposited tubes.** Elmore. (Second edition.)

12628. **Welding metals by electricity.** Fowler. (Second edition.)

1893.

238. **Galvanometer.** Sullivan.

660. **Battery elements.** Pickard and Thame.

3101. **Insulating armatures of dynamo-electric machines.** Jefferson.

3831. **Telephone exchange systems.** Kingsbury. (Western Electric Company.)

4390. **Electric arc lamps.** Cannevel.

4772. **Metal arms for supporting telegraph insulators, etc.** Marsh.

21630. **Telegraphy.** Delaney.

22253. **Railway electric signals.** Bradrick and Karr.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	2⅜
— Pref.	—	2¼
Charing Cross and Strand	—	5
City of London	—	11½
— Pref.	—	13½
Electric Construction	—	1⅜
House-to-House	5	2
India Rubber, Gutta Percha & Telegraph Co.	10	22½
Liverpool Electric Supply	5	6¼
	3½	4⅜
London Electric Supply	5	1
Metropolitan Electric Supply	—	8⅜
National Telephone	5	4¾
St. James', Pref.	—	8½
Swan United	3½	3½
Westminster Electric	—	5⅛

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NOTES.

Scarborough.—The Sanitary and Lighting Committee of the Scarborough Corporation have resolved to introduce the electric light in the Town Hall.

Legal.—Dr. Tibbits has again been unsuccessful in his actions brought against newspapers for alleged libel. This time it is the *Morning* which has won the day.

Harrow.—A Local Government Board enquiry will shortly be held with respect to the application of the Local Board to introduce the electric light in the district.

Blackpool.—As mentioned in another column, the Blackpool Town Council voted the sum of £24,000 on Tuesday for extensions of the electric light works.

Wigan.—The Town Council are granting an extension of time for householders to send in replies regarding the supply of current, and they have also modified their terms.

Wiring.—The Shoreditch Vestry have commenced an artisans' class in wiring and fitting work at a nominal fee of 2s. 6d. per term at the Municipal Technical Schools, 35, Hoxton-street.

Mill-Lighting.—The members of the Ramsbottom Local Board recently inspected the electric light installation fitted up in the mills of Mr. Alexander Barlow, Bridge Mills, Edenfield.

The Heilmann Locomotive.—It is stated that the experiments in electric traction made at Havre, under the auspices of the Western Railway of France, have yielded satisfactory results.

Leeds.—The Corporation have now taken over the undertaking of the tramways company. A decision has not yet been arrived at as to what system of traction will be adopted on the lines.

Sunderland.—On Wednesday the Town Council decided to accept tenders for the erection of an electric lighting station, subject to the sanction of the Board of Trade and the Local Government Board.

A Peculiar Accident.—An explosion of gas occurred in the Philharmonic Restaurant at Cardiff on Monday, in connection with a gas-engine used for driving a dynamo lighting the premises. Three men were injured.

The Royal Agricultural Society Show.—The Duke of Devonshire presided on Wednesday at a council meeting of the Royal Agricultural Society of England, when an invitation to hold next year's show at Darlington was accepted.

The Guilds Central Technical College.—The Executive Committee of the City and Guilds of London Institute have changed the name of the Guilds Central Institution in Exhibition-road to that of the Guilds Central Technical College.

Traction at Cardiff.—Mr. S. Hern, a director of the Cardiff Tramway Company, stated a few days ago that if the electric light plant became available for propelling tramcars, the company would take every opportunity of introducing that method.

Battersea Polytechnic Institute.—No less than 159 students have enrolled themselves in the mechanical engineering department, and there are 111 students in the classes dealing with electrical subjects, that in electric wiring being the most popular and largely attended.

Stafford.—The Electric Lighting Committee of the Town Council recommended on Wednesday that tenders should be invited for the construction of a dynamo and engine house, with a two-storey building to be used as a store, testing-room, offices, etc. The report was adopted.

Lighting in Kensington.—During the past year the number of houses and shops connected with the system of the Kensington and Knightsbridge Electric Lighting Company has increased from 550 to 734, while the number of lamps calculated on the basis of 8 c.p. has increased from 47,441 to 64,529.

The "Medical Battery" Company.—The week allowed by Mr. Hannay for the prosecution in the Harness case to consider whether they would proceed under the Vexatious Indictments Act having elapsed, and they having taken no steps in the matter, the case may now be considered at an end.

Holyhead.—The price of gas for illuminating purposes has recently been advanced by the local company to 5s. per thousand. Complaints against this are now being made, especially in view of the decision to supply gas for cooking purposes at 3s. 10d. The introduction of the electric light should prove a great success.

Proposed Colombo Electric Tramways.—A correspondent writes to a Ceylon paper pointing out various objections to the proposal to lay electric tramways, and suggesting that omnibuses would be much more suitable. The Ceylon paper says that it would be well to wait until it is seen how the Madras scheme works.

Another Belt Case.—Francis McOnville, *alias* Prof Hamilton, has been committed for trial at Liverpool on a charge of obtaining £50 by false pretences from John Gardner, by representing that he was a medical man, and that an alleged "electrical belt" which he sold to Gardner would cure a disease from which he was suffering.

Electric Lighting of Pianos.—A demonstration has just been given of a method of lighting pianos by electricity. The current is obtained from an accumulator which will give light for between 18 and 20 hours. Each lamp—there is one on each side of the piano—gives a 3-c.p. light. The battery is contained in a receptacle behind the music desk.

Lectures.—A lecture on "The Scientific Work of Galileo" has this week been delivered by Prof. Fleming before the members of the Leeds Philosophical and Literary Society. Under the auspices of the Yorkshire Ladies' Council of Education, a lecture has been delivered in Leeds by Mr. Robert Hammond, M.I.E.E., on "The Electric Light in our Homes."

Society of Arts.—The fourth Cantor lecture on "The Detection and Measurement of Inflammable Gas and Vapour in the Air," by Prof. Frank Clowes, D.Sc., will be delivered on Monday. On Wednesday next, at 8 p.m., Prof. Henry Robinson will read a paper on "The St. Pancras Electric Light Installation." Mr. W. H. Preece, C.B., F.R.S., will preside at this meeting.

British North Borneo.—A correspondent of a daily paper mentions that in 1889 the Eastern Telegraph Company, at the request of some of the subsidiary companies in North Borneo, proposed to connect Borneo with Singapore and Hong Kong. The proposal was favourably reported on by Admiral Salmon on behalf of the Imperial Government, but the scheme fell through owing to want of support by the Chartered Company.

Institution of Mechanical Engineers.—A reception committee, with the Lord Mayor of Manchester as chairman, and the Mayor of Salford as vice-chairman, has been formed in Manchester in view of the visit of the Institution of Mechanical Engineers to Manchester this year. It was mentioned that the visitors would have the Ship Canal, the electric light station, the hydraulic power plant, the sewerage, and the Thirlmere waterworks to see on this occasion.

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A Funeral Car.—An electric funeral car has recently been constructed by one of the San Francisco tramway companies for the San Mateo Cemetery, at a cost of £500. The car has been named "Cypress Lawn." It is 30ft. in length, and is divided into two compartments—the forward 20ft. in length, and the rear 10ft. As San Francisco has an extensive system of electric tramways, the car can be employed throughout the city, and will, it is said, to an extent supersede the use of hearse and carriages for funerals.

Books Received.—We have to acknowledge receipt of the following: "Induction Coils and Coil-Making," by F. C. Allsop (E. and F. N. Spon); "The Electric Transformation of Power," by Philip Atkinson, A.M., Ph.D. (Crosby Lockwood and Son); "The Inventions, Researches, and Writings of Nikola Tesla," by T. Commerford Martin (the *Electrical Engineer* of New York); "Electricity in the Service of Man," by R. Wormell, D.Sc., M.A., and revised and enlarged by R. Mullineux Walmsley, D.Sc.(Lon.), F.R.S.E. (Cassell and Co., Limited).

Huddersfield Electric Light Station.— With reference to the description of this station, given in our issue of the 26th ult., we are requested to publish the following statement concerning the efficiency of the plant: "Although the station has only been at work a few months, the results already attained (and which will no doubt in due course be published) are exceedingly satisfactory, the cost per unit supplied to the customer, as shown by carefully compiled returns, being considerably lower than any hitherto published."

Japan.—It appears that Japanese electrical engineers are devoting attention to the drawing up of elaborate plans for the utilisation of water power and the construction of electric railways. At Uwajima, Ehimé-Ken, it is proposed to construct an electric railway between that town and Nakamura, a distance of 50 miles, the Semba Falls in Kita-Uwa-gun to be utilised as the motive power. Another proposed line of electric railway is between Takidani, Kobe, and Yuamacho, a distance of 15 miles. In this case it is proposed to utilise the waterfalls in Arino-mura.

Electrically-Lighted Lifebuoys.—Some trials have just been made at Kiel on board the German war vessel "Wörth" with an electrically-lighted lifebuoy, the invention of Captain Melter. The buoy, according to *Industries*, was thrown overboard when the vessel was proceeding at a speed of about 16 knots. For a space of about 12 seconds it was lost in the eddy current caused by the twin screws of the vessel, but then reappeared. The new lifebuoy will be found useful at night time, and the experiments resulted so successfully that it is probable that it will be adopted generally in the German navy.

The Edison Lamp.—It appears from a recent decision of Judge Shipman, in the United States Circuit Court for Connecticut, that the introduction of an inert gas into the bulb of an incandescent lamp does not avoid the Edison lamp patent. The specific point at issue was the asking for an injunction by the Edison Company against the manufacturers of the "Novak" lamp, which was thought by many to not infringe the Edison patent, for the reason that bromine gas was introduced into the bulb. The Court held that the "Novak" lamp embodies the entire invention of Edison, and the manufacturer thereof should be enjoined.

Engineers and Shipbuilders.—The fifth general meeting of the North-East Coast Institution of Engineers and Shipbuilders will be held on Tuesday, the 13th inst., in the Physical Lecture Hall of the Durham College of Science, Newcastle. A discussion will take place on Mr. Frank Caws's paper, "On Certain Principles of Motion, as taught by the Pendulum, and as illustrated by the Resistance of Ships, and other bodies moving through fluids, together with a brief sketch of the Pendulum Speed-Power Meter." A paper will be read "On a New System of Construction for Large Vessels of Cellular Type," by Mr. William Bell.

Traction at West Hartlepool.—The Town Council this week discussed the report of the Works Committee. The chief feature of this was a recommendation of the sub-committee which visited Leeds to inspect the electric tramway to the effect that they found it to be working satisfactorily, and that the Council be recommended to approve of the system, to be laid down from a point commencing at the police station and continuing to the borough boundary, subject to the poles being erected on one side of the road only. Considerable discussion ensued as to the proposal regarding the poles, and an amendment referring this portion of the question back to the committee was carried.

The Phonograph Patent Action.—An action brought by the Edison-Bell Phonograph Corporation against Mr. G. A. Smith and Mr. Young has been decided. It was a patent case which has occupied the Court for a considerable time. The action was for damages and an injunction in respect of infringement by the defendants, G. A. Smith and J. L. Young, of a patent for improvements in connection with phonographs, taken out by Mr. Edison, and by him assigned to the plaintiff company. His Lordship last week gave judgment for the plaintiffs, with costs, and granted a certificate of the validity of the patent, and an injunction against the defendants. He added that he would subsequently give the reasons for his judgment.

The British Association.—The council of the British Association has confirmed the nomination of the following presidents of sections for the meeting at Oxford, the commencement of which has been fixed for August 8: Section A (mathematical and physical science), Prof. A. W. Rücker, F.R.S.; B (chemistry), Prof. N. B. Dixon, F.R.S.; C (geology), Mr. L. Fletcher, F.R.S.; D (biology), Prof. Bayley Balfour, F.R.S.; E (geography), Captain W. J. L. Wharton, F.R.S., hydrographer to the Admiralty; F (economic science and statistical), Prof. C. F. Bastable; G (mechanical science), Prof. A. B. W. Kennedy, F.R.S.; H (anthropology), Sir William Flower, K.C.B., F.R.S.; I (physiology), Prof. E. A. Schafer, F.R.S. The last is a new section resolved on at the Nottingham meeting of 1893.

Expiration of the Bell Telephone Patent.—The second fundamental Bell telephone patent expired at the end of January. The carbon transmitter is still protected to a great extent by fundamental patents of uncertain validity. Among these the Berliner patent of November 17, 1891, has become celebrated; its tenure of life is now the issue in a suit brought by the United States Government for its annulment. Then there is the Edison patent of May 3, 1892, of uncertain validity, owing to the English patent for the same invention, which expired before the American patent was granted. The fate of this patent will depend largely on a decision in a case now pending in which the same point is involved. The whole affair is quite complicated, and its complication appears greater when the quantity of minor patents held by the Bell Telephone Corporation are considered.

Gas Monopolies and Electric Lighting.—Disputes have arisen of late years between gas companies and municipalities on account of the violation by the latter of contracts entitling the companies to a monopoly. According to a correspondent of the *Times*, St.-Etienne and Montluçon were three years ago ordered by the Council of State to compensate the companies for allowing the introduction of the electric light. On the 2nd inst. the same

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tribunal gave judgment in favour of a claim for the assessment of damages by the gas company of Argentan against the municipality. The latter had not only allowed an electric light company to lay down wires, but had allowed it the use of a site for its works. The judgment contains a recital that, whenever a gas company has been accorded a monopoly for any fixed period, compensating advantages have always been guaranteed to the local authorities in the shape of cheap rates or participation in profits.

Lighting in the Crystal Palace District.—Mr. George Offor, the managing director of the Crystal Palace District Electric Supply Company, has issued a pamphlet containing testimonials received from consumers during January concerning the efficiency and cheapness of the supply of light by the company. Mr. Offor directs special attention to the letter of Mr. J. S. Sellon, in whose opinion the indirect economies and the saving in health resulting from a pure atmosphere really dispose altogether of the quarterly accounts for the electricity, leaving the cost "not much greater than that of the light of the sun." The testimony of Messrs. Sydney Smith and Sons, after employing in their extensive establishment both gas and electricity, is that the cost of the latter is half as much again as gas, but with twice the light power. The company's mains are laid in various thoroughfares, where a constant supply of electricity, day and night, can be obtained at 8d. per Board of Trade unit, delivered by meter, which is given as equivalent to one farthing per hour for 8 c.p.

Telephony in Manchester.—The Parliamentary Sub-Committee of the Corporation have presented a report dealing mainly with the subject of telephone wires. The report contained a copy of a letter addressed to the Lord Mayor by the general manager of the National Telephone company, complaining that no answer had been received to the application made by the company to the Council for facilities to place certain of the company's wires underground. It was stated that there was grave danger, which was becoming accentuated by delay, of the dislocation of the telephone service. The general manager added that the necessary instructions had been given for reconstructing the company's telephone system in Manchester on the metallic circuit principle, by means of overhead wires. Having regard to this letter a motion has been adopted by the Corporation authorising the sub-committee to enter into direct communication with the National Telephone Company in regard to the laying down of underground wires within the city, and to report the result of such negotiations.

Testimonial to Principal Garnett.—In connection with the movement for the presentation to Principal Garnett of a testimonial from students of the Durham College of Science, Newcastle-on-Tyne, a preliminary meeting of subscribers was recently held in the college, Mr. G. H. Burkhardt, A.Sc., treasurer of the fund, in the chair. The chairman laid before the meeting the steps which had been taken to bring the movement before the notice of all past and present students, and stated the result of these efforts. It was agreed that as Dr. Garnett will remain principal of the college until June, when the present session ends, the subscription-list should remain open until Saturday, April 21. It was thought that in this way a large number of students, before whose notice the project had only quite recently been brought, would be afforded a better opportunity to subscribe. A resolution was also passed leaving the selection of the form of the testimonial to the committee, with a proviso that its numbers be increased by the addition of students from those sections which do not appear to be adequately represented at present. For this purpose meetings of the various sections will be held in the college at suitable times within the next two or three weeks. We understand that a full statement of the position will be laid before each of these meetings, so that every student may be brought closely into touch with the work of the organising committee. We may add that the individual subscription is limited to five shillings.

"Lockwood's Builder's and Contractor's Price-Book."—Certain portions only of "Lockwood's Builder's, Architect's, Contractor's, and Engineer's Price-Book for 1894," which has just been published by Messrs. Crosby Lockwood and Son, appeal directly to electrical engineers and contractors. The work forms a comprehensive handbook of the latest prices of every kind of material and labour in trades connected with building, including a large variety of the most recent information in all matters concerning these branches. The present edition has been rewritten, enlarged, and edited by Mr. Francis T. W. Miller, A.R.I.B.A. Of the sections dealing with electricity may be mentioned a short article on the supply of electricity, this being followed by particulars of output and price of dynamos, alternators, and accummulators made by different firms; of arc lamps, carbons, incandescent lamps, fittings, and accessories, electric bells, etc. The handbook also contains copies of the conditions under which the City of London Electric Lighting Company supplies electrical energy, and of the well-known rules of the Phœnix Fire Office for electric light and power installations. The "Price-Book" can be well recommended as a valuable work of reference.

The Prize for an Improved System of Traction.—In addition to the systems referred to in our last issue as competitors for the prize of £10,000 offered by the Metropolitan Traction Company for a railway equal to the trolley system, without overhead or other objectionable features, may be mentioned a method devised by Mr. William Lawrence, of the Lawrence Electric Company, New York. In this system a conduit of vitrified clay and a sectional trolley wire normally out of contact with the feed wire, and entirely dead except during the passage of a car, are used. The conductor sections are of copper wire 32ft. long, each soldered along the flange of a piece of angle iron of the same length, and of sufficient cross-section to be quite rigid when supported only at its extreme ends. At the end of each section is a watertight and airtight junction-box with a heavy rubber top through which projects a pin adapted to be screwed to the end of an angle-iron section and to support it in position. The lower end of this pin in the box is provided with copper brushes that make contact with a copper plate below when depressed. The weight of the section, however, is not great enough in itself to force it downward, and it is kept by the air pressure in the box, and by the elasticity of the rubber top, from completing the circuit except during the passage of the car. The feeder is wholly insulated and all connections are made within the boxes. The car carries a double trolley making contact with one section of conductor before that with the last is broken, in order to minimise the tendency to sparking. An experimental line on this system will shortly be demonstrated.

Private Installations at Maidstone.—A private installation of the electric light has recently been completed on the premises of Messrs. Richard Dann, of High-street, Maidstone. The generating plant comprises a "Taunton" 26-unit dynamo, wound as a shunt or compound, with a switch to open or close the series coil. It is driven by a "Trusty" gas-engine. There is a battery of 23 L-plate E.P.S. cells, connected in shunt with the machine in the usual way, excepting that some larger cells of three times the capacity have been fixed on the regulating switches, thus enabling the "heavy load" current to be put

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through these regulating cells, and so check the E.M.F. in the lamp circuits and charge to their full charging capacity the main battery of cells during the lighting hours. By this arrangement the engine and dynamo can be run at full load, and consequently at high efficiency, for nearly the whole of the lighting hours, charge the batteries for two-thirds the time and discharge for one-third the time, and supply lamps during the daytime from the remaining charge. There are about 300 16-c.p. 100-volt lamps on the mains, and several arc lamps and large-power incandescents fixed in the showrooms and on other premises. Owing to the unequal distances of the consumers' premises from the generating station, it became necessary to transmit the current at graduated E.M.F.'s to make up for the loss in transmission through the mains. To do this economically a separate pair of mains was carried to each consumer, and a separate cell-regulating six-point switch arranged to each. The switchboard is also fitted with the usual measuring instruments and accessory switches and plugs, and safety cut-outs and devices. The installation was carried out by Mr. Chas. Rawlings, assisted by Messrs. T. Price and A. Clark.

Birkenhead.—The proceedings of the Finance Committee presented at a meeting of the Town Council on Wednesday contained a report by a special sub-committee with reference to the steps to be taken in regard to the carrying out of the provisions of the Birkenhead Electric Lighting Order, 1890. The sub-committee stated that they had, with a view to obtaining information as to the system of electric lighting best suited to the requirements of the borough, obtained reports on the subject from Dr. Hopkinson and Mr. J. N. Shoolbred. The sub-committee were of opinion that the time had arrived when the circumstances in connection with the steps to be taken under the Birkenhead order demanded that an electrical engineer should be appointed to advise the Corporation as to the details of the system of electrical illumination to be introduced. The sub-committee therefore recommended the appointment of Mr. J. N. Shoolbred. The sub-committee had also considered with Mr. Shoolbred the question of a suitable site upon which to erect the necessary central generating station, and they recommended that they should be authorised to select and purchase a site in a suitable locality as they might be advised by the electrical engineer. Alderman Deakin moved the adoption of the report, and said that some four or five years ago legislation was passed whereby companies and others undertaking electric lighting works were placed in a very favourable position. In Birkenhead, when they saw the powers which might be conferred by the Board of Trade by means of provisional orders, and when they saw several companies applying for those orders, they came to the conclusion that they ought themselves to apply for the order, and an application was accordingly made and granted. They had been told by the engineer that they could make a beginning with a capital of £14,000 or £15,000, which did not include the value of land or professional services. Although at first it might not be profitable, it was thought that a long time would not elapse before it would pay expenses. Mr. Gostenhofer seconded the motion, which was adopted with a slight modification concerning the site.

Vibration.—At the last meeting of the British Association, Mr. W. W. Beaumont read a paper on the automatic balance of reciprocating machinery, and on Wednesday last supplemented this with another paper read at the Society of Arts. The subject is extremely interesting, and points once more to the blindness of ordinary mankind. It would be difficult to determine how great progress has often been made by going backward. Let us explain. A certain result is often aimed at and obtained. In getting that result damaging opposition is overcome, and in the case of manufactures by-products are produced which for the nonce are thrown aside. By-and-by someone comes along, takes up these by-products, and shows that they are more valuable than the direct result; and we progress by going backward. Prof. Hughes told us how to make telephony practicable by taking advantage of bad contacts. Now Mr. Beaumont is telling us how to get rid of vibration by deliberately allowing it and using it to kill itself. Electrical engineers are greatly concerned in minimising vibration, and the last paragraph of this paper will appeal directly to them. It is as follows: "The fact that this wall moves is a proof that there is something connected with it that wants to move and we will not let it, or wants to move more than we will let it. Now, this is bad policy, and the lesson to be learned from it is that as we cannot stop the unbalanced thing from moving, we had better make our calculations afresh on the assumption that that fact must not be ignored, and that it must be allowed to move. It is no use trying to stop it, unless we give it something to expend its energy upon. We must let it move because we cannot help it, but we can help letting it move without taking toll. It is one of those 'forces in nature which we must direct for the use and convenience of man,' and in a general way it may be said that when a piece of mechanism wants to wobble, it is obviously either wrongly constructed, or if it is not and wants to wobble, then let it wobble, but make it wobble something you want wobbled. In most cases it will not wobble so much, and never so forcibly, if we don't try to stop its wobbling."

Utilisation of the Irish Sea Tides.—An article on the above subject, by Mr. W'r. Lodian, is published in the *Electrical Engineer* of New York of January 24. We extract the following: "The author states that in February last he concluded a series of hydrographic surveys on the Antrim coast of Ireland. He was specially detailed to report upon a project to connect Britain and Ireland by a land junction. It was pronounced practicable, but the question was asked: What is the use? The primary feature of the projected land junction will be its power-houses, and their use in the generation of electricity from the strong currents always prevailing in that part of the Irish Channel. The water power there running to waste is such that, if utilised, power and lighting could be supplied to the districts for hundreds of miles around. Two power-houses would be ample; one for supplying the Scotch side, the other for the Irish side, and a railroad would run along the isthmus from Cantire to Antrim. While in the present state of the project, it would be 'too much to reveal too much,' a few extracts may be made from the official specifications, which will show what the constructing engineer proposes to do, and how. In a direct line north-west of London, about 365 miles, and north of Dublin about 126 miles, is the narrow passage between Ireland and Scotland, at the Mull of Cantire The Gulf Stream supplying the continuous current flows from the North Sea into the Irish Sea in volumes of water estimated at many cubic miles daily. The waterway between the headland of Cantire in Scotland and Torhead in Ireland is 15 miles wide, 474ft. deep at mid-current, but much shallower towards either shore. This is the position selected as offering the best engineering facilities for the creation of an isthmus as shown on the chart. The high bluffs of Cantire and the still higher land comprising mounts Clady, Escart, and Carnlea near the Irish coast, from 900ft. to 1,200ft. high, offer facilities for gravitating

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the materials requisite to form the isthmus between the opposite shores. The superficial extent of land required to form the isthmus would be a little more than a square mile, of the average width and depth of 100 yards. There are no engineering difficulties in the way to prevent the immediate commencement of the undertaking, if favoured by national approval and commercial enterprise. The cost of creating the isthmus would be about two million pounds sterling, and the time it would occupy would be about three years. To maintain a passage of ships to and from the North Sea to the Irish Sea, the Canal of Crinan might be enlarged and another cut through the Isthmus of Tarbert."

The Faulty Wiring of Vessels.—The *Pall Mall Gazette* has followed up its article on "A Needless Ocean Danger," of which we gave an abstract last week, by reports of two interviews with persons interested. The first was with Captain Froud, lieutenant R.N.R., the secretary of the Shipmasters' Society. Captain Froud contends that the existing condition of defective wiring is chiefly due to the absence of supervision. He agrees that a deck officer and an engineer of each crew should be the certified possessors of certain electrical knowledge, and that for this remuneration should be commensurate. Much good, he opines, would be done if Lloyd's surveyors inspected the electrical arrangements, or retained specialists to do so, and withheld their highest mark in cases where there were unnecessary risks. The second interview took place with an electrical expert, who said that it was extraordinary that the system of putting up installations on board ship had got in a vicious state. Personally, he did not blame the contractors. His experience was that the contractors, in many cases, had put in as good material and as good work as they could possibly afford to do for the price they had been paid. Continuing, he remarked: "The whole system has got into a vicious condition. Contracts are put up to tender, and go to the lowest, with practically no specifications whatever except the contractor's own. Then there is no supervision of the work in many cases by any independent consulting engineer, and if the work complies with certain tests as to what the dynamo can do and so on, the job is passed as a matter of course." Asked as to what was the possible saving to the contractor between good and indifferent work, he replied that it might be 50 per cent. He observed further: "I do not think good firms can do the work in the way that, in my opinion, it ought to be done at the prevailing prices. As with all such matters, if a fair price be paid, and a consulting engineer retained to supervise, it would be a solution of the whole matter. Any work might get into the same condition that this electric lighting of ships has got into with unlimited competition without supervision. Let the specifications be written out by competent electrical engineers, who should take into consideration, of course, as they do with buildings, the fire risk aspect as well as that of the illumination. Then let the contractors tender upon those specifications, and then if the work be subjected to supervision during its progress, and if the contractors be paid on the certificate of the electrical engineer on the completion of the work, we should get the same satisfactory condition of affairs with regard to ships as we have already obtained, by similar means, with regard to buildings. That would be a much better way than by any Government interference, for I do not believe in the incessant invoking of Government."

The Electrolysis of Sea-Water.—In the course of a communication to the *Lancet*, a correspondent at Havre says: "The town of Havre determined to give M. Hermite every facility to carry out his process, and at first the experiments caused considerable enthusiasm. Buoyant hopes were entertained that a solution had been found for the difficulties which beset this town. Havre, as I described when dealing with the cholera epidemic of 1892, drains its refuse into the gutter. When the water that conveyed the household slops and also the sewage from the closets had been charged with chlorine, there was not only an absence of bad odour, but the gutters, always more or less black and soiled, were beautifully bleached. The kerb and flagstones became white, as if they had just left the quarry. The effect was drastic, and loud were the praises raised. The municipality of Havre, however, appointed a technical commission to enquire into the process. The following is an abstract of the description given by M. Hermite of the works he established at Havre. These were situated at the Pont d'Angoulême, where the cost of labour, fuel, etc., amounted to 70f. a day. In England, where labour is not so cheap, this would have cost £3, or probably £3. 3s., per day. There were two steam-engines of 35 h.p., and two complete and separate electrolysing machines, each carrying two electrolysers. Three rotary pumps propelled the liquid disinfectant up to a reservoir 12 metres above the works. There was a rotary pump to draw up the sea-water and discharge it into the electrolysing tanks, and another pump to fill the reservoirs with electrolysed water. From these reservoirs the water could be delivered to the houses where the experiments were made. Under normal conditions each electrolyser should work as follows: 1,200 amperes × 5·5 volts = 6,600 watts; $\frac{6,600\text{ w}}{736\text{ w}} = 8{\cdot}96$ electric horse-power; this + 20 per cent. = 10·75 mechanical horse-power. To this should be added the necessary force for the circulation and transmission pump, which gives a maximum of 12 h.p. for one electrolyser, or 48 h.p. for the four electrolysers Under these conditions the normal production would be one kilogramme of chlorine (*chlore*) per hour per electrolyser, and this would give two cubic metres of liquid containing 0·5 gramme of chlorine per litre per hour, or four cubic metres of the solution at 0·25 gramme of chlorine per litre per hour. But M. Hermite stated to the municipality of Havre that the velocity of the machinery was insufficient, and that the average intensity of the electric current for each of the two electrolysers was 925 amperes × 11·25 volts = $\frac{10,406\text{ w}}{736\text{ w}} = 14$ electric horse-power; this + 20 per cent. = 16·8 mechanical horse-power. Adding to this the power for the pumps, the total reached was 18 h.p. for each of the two electrolysers. The installation produced on an average one gramme of chlorine per hour per ampere, or 925 grammes of chlorine per electrolyser, or, for the four electrolysers, 925 × 4 = 3,700 kilogrammes of chlorine per hour. They were therefore able to produce one cubic metre of liquid containing 0 5 gramme of chlorine per litre in about eight minutes, and at the rate of 0·25 gramme of chlorine in four minutes. In the Rue d'Edreville a house with 35 inhabitants was supplied for the closets with 180 litres per 24 hours, or about five litres per inhabitant. In the Rue Fontaine a house with 30 inhabitants was supplied with 350 litres, or 11·5 litres per inhabitant, and there were 150 litres for some automatic flush-tanks, or 500 litres in all—that is, an average of 16·5 litres per inhabitant. M. Hermite thinks that there should be 20 litres per head at 0·25 gramme of chlorine per litre. He stated that he was able to guarantee a supply of 1 kilogramme of chlorine per hour per electrolyser for a motive power of 12 h.p., which would be equivalent to 48 cubic metres of the disinfectant in the 24 hours at a strength of 0·5 gramme of chlorine per litre, or, as he seemed to prefer, 96 cubic metres at 0·25 gramme per litre."

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THE KINGSTON CORPORATION ELECTRIC LIGHTING STATION.

The idea has for some time been prevalent amongst many that an electric lighting central supply station owned and operated by the local authority can only be established with success, from an economical standpoint, in districts of considerable size, and also very thickly populated—that is, in the present state of the electrical arts, only large towns and cities are practically justified in taking up the supply of electric energy for public or private purposes.

Instances, however, of highly successful stations even equipped on a small scale are by no means wanting; and we need go no further from London than Kingston-on-Thames to find a supply station of good design and carefully thought-out construction.

It is situated close to the gasworks, between them and the South-Western Railway, being also only a few yards from the River Thames, and occupies practically a portion of the Kingston Corporation Drainage and Streets Committee's land. Being a municipal undertaking, it has throughout been in the hands of the borough surveyor, Major Macaulay, more especially as regards the buildings, the chief character of which is a neat substantiality.

The main block itself is of an irregular oblong shape, in plan, as may be seen from the annexed engraving; the main front and sides—of red brick—are, of course, permanent, but in the rear the outer wall is more or less of a temporary nature, so that extensions may conveniently be made when more energy is required to satisfy public demands for light and power. At present there are seven sets of steam-dynamos erected, space being left in the building, as it stands, for one large set—of 150 h.p.—and another boiler.

Sectional Elevation of Buildings—Kingston.

The front entrance of the building opens into a hallway and a suite of offices and stores on the ground and first floors: passing thence through a door, one enters the engine-room, a building about 40ft. square, with a height of 23ft. Windows on the one side give all necessary light, though, if required, still more can be obtained by opening up large doorways in the back wall, through which all the heavy plant is introduced. A five ton overhead hand traveller, worked by chain, has been erected for this latter purpose, and for lifting heavy parts of engines or dynamos at any time. A louvre ventilator in the roof serves to carry off the heat and steam that may arise.

The main steam supply piping is brought in from the adjoining boiler-house, so as to form a complete ring round one half of the engine-room: branches are taken from this to the different engines, and large stop-valves allow them to be operated from one or other half ring as may be desired. In the space enclosed by the ring, between the centre line and side wall, are erected two 75-h.p. steam-dynamo sets. These each comprise one of Belliss's self-lubricating compound vertical engines, driving direct a Siemens alternator with an output of 24 amperes at 2,100 volts and a speed of 460 revolutions per minute. These machines are employed for the incandescent lighting; but, of course, their full output is not as yet taken up, though very satisfactory progress is being made with installations in shops and private houses.

On the other side of the engine-room there are erected, first, two 30-h.p. engines of similar type to the above, each coupled up direct to a Siemens continuous-current machine, for arc lighting. At present there are only 36 street lights in use, in two series of 18 each, so that one of these machines is practically spare or held in reserve, the other being fully able to take the whole load. They each give 20 amperes at 950 volts, and run at a speed of 550 revolutions per minute.

Next to these, there come two 25-h.p. engines, driving direct a couple of shunt-wound continuous-current machines by Siemens, which are used to excite the fields of the large alternators, and can also supply current for the lamps erected throughout the station itself. These give 160 amperes each at 105 volts, the speed being the same as those last mentioned. Either machine is sufficient for the total work required at present, and there is consequently ample reserve power.

The remaining set consists of a 40-h.p. engine coupled directly to a Siemens alternator giving an output of 12 amperes at 2,100 volts, at a speed of 580 revolutions. This machine serves to take the light loads in the daytime, etc., and until the demand increases, it also obviates the necessity of running both the large alternators simultaneously. In this connection, of course, it must be borne in mind that the whole station has only been at work for a couple of months or so, and the number of consumers therefore cannot be expected to increase so rapidly as at once to take up the whole output. The question of reserve power has been studied so carefully that the capital outlay on surplus plant must have been a minimum for a station of this character, and the arrangement of units adopted might be followed with advantage by other local authorities who fear the inefficiencies of light load in generating plant of large output.

Adjoining the engine-room is a boiler-house, measuring 50ft. by 40ft., with a height of 20ft. This contains at present a couple of large horizontal double-flued multitubular boilers, constructed by Messrs. Belliss and Co., with room for a third alongside. These boilers are each 22ft. 6in. long, with a diameter of 7ft. 2in., and work at a pressure of 150lb. to the square inch; they are fitted with Bennis's mechanical stokers, and besides the usual mountings have an isolating stop-valve, so that any one may be cut off from the steam supply pipe when desirable. Their flues join at right angles into a main smokeway at the back, underground, which is connected to a Green's economiser, with pivoted dampers and a by-pass into the chimney flue. This latter runs underground along the outside of the boiler-house front wall, terminating in the base of a large brick chimney stack.

In the boiler-house there is found room for a very complete system of surface condensing apparatus: this includes a horizontal surface condenser with a total cooling surface of some 1,000 square feet, operated by a double-acting vertical air-pump. A centrifugal pump, driven by a small vertical single-cylinder engine, serves to circulate the cooling water through the condenser; the water is obtained

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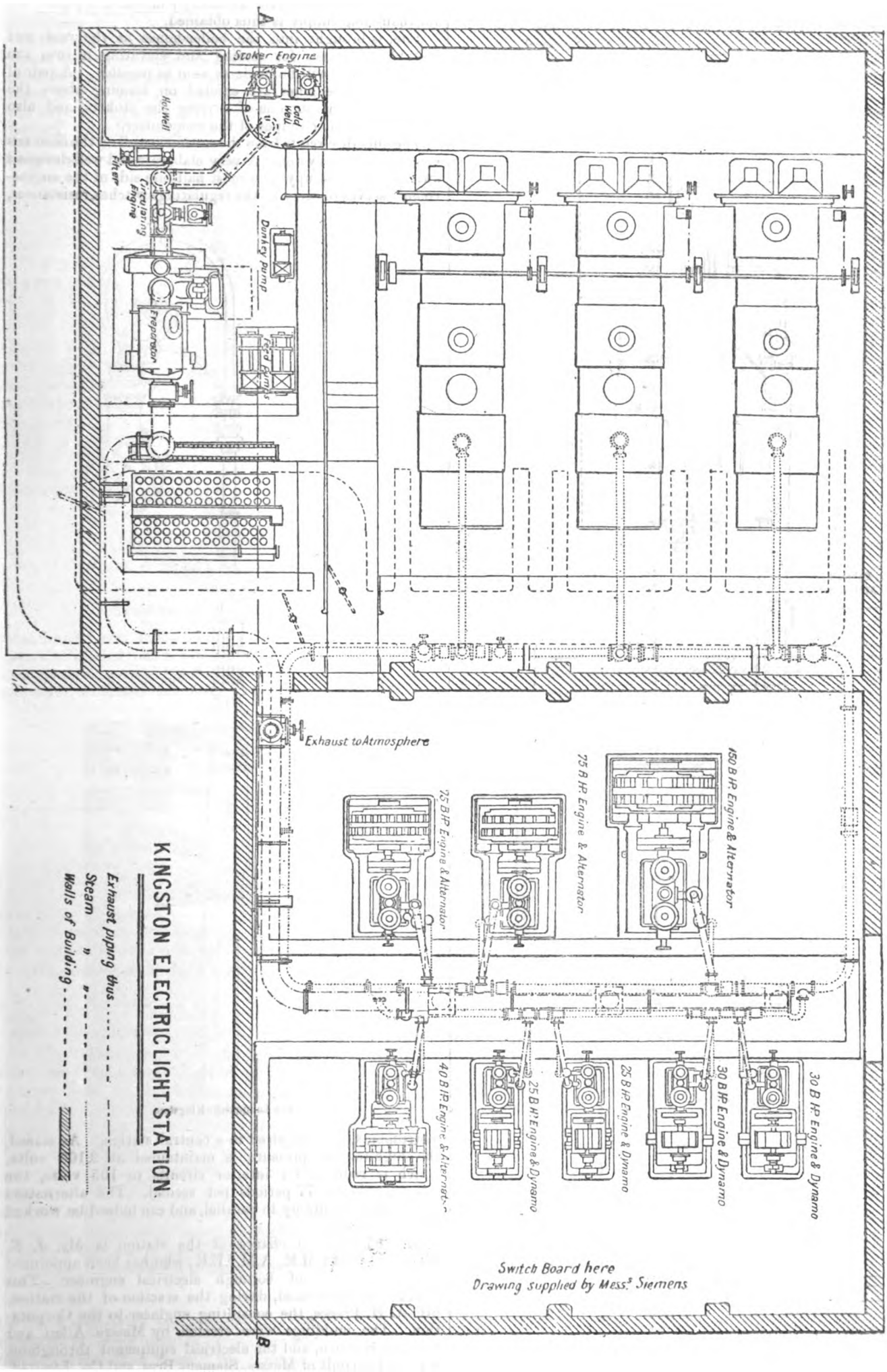

Plan of Kingston Electric Lighting Station.

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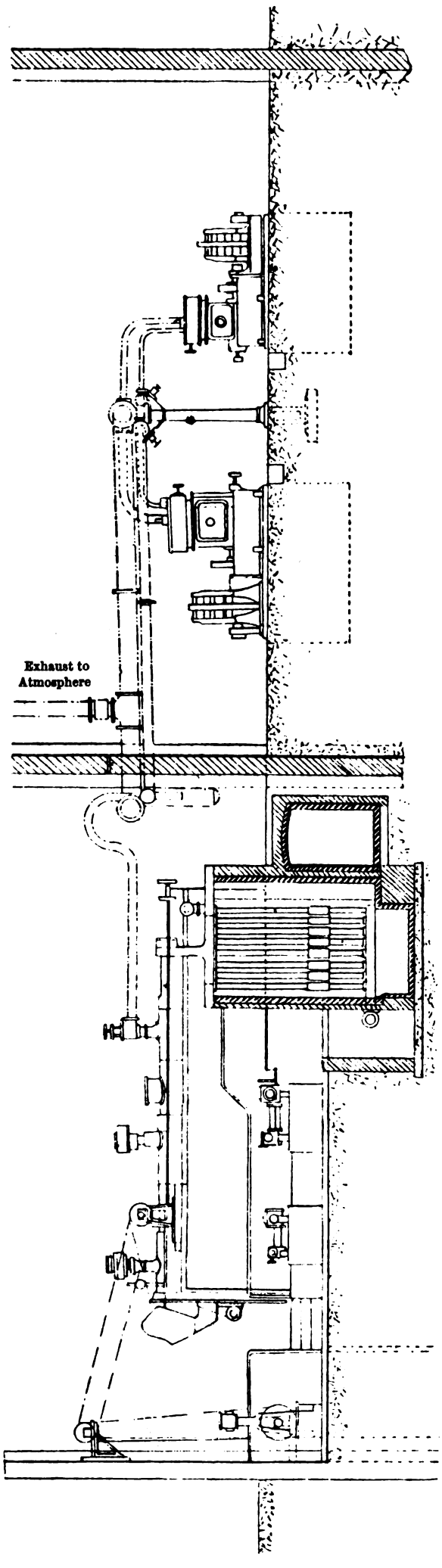


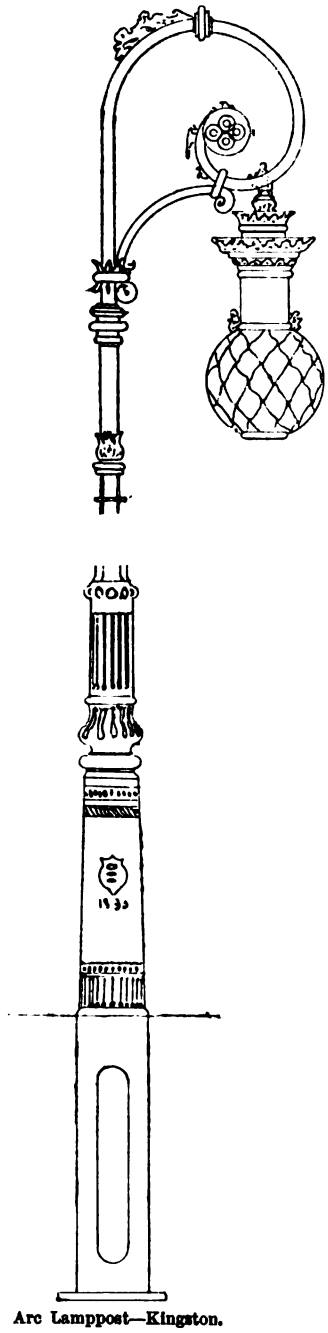
Sectional Elevation on A.B.

Sectional Elevation of Electric Lighting Station—Kingston.

from a cold-well sunk underneath the boiler-room floor and connected with the River Thames by means of a pipe. An inexhaustible supply is thus obtained.

Fuel is brought into the boiler-house at the rear, and suitable provision for storing and elevating it into the stoker hoppers will be made as soon as possible. A pair of small vertical engines are erected on framing above the cold-well for the purpose of driving the stokers, and also the scrapers on the pipes of the economiser.

The outside circuits from the station are all on the Siemens concentric cable system. A very elaborate and well-designed switchboard—occupying almost half one side of the engine-room—serves to carry all the regulating switches, resistances,



Arc Lamppost—Kingston.

instruments, etc., required in a central station. As stated, the high-tension pressure is maintained at 2,100 volts, which is reduced for interior circuits to 105 volts, the frequency being 77 periods per second. The alternators are worked absolutely in parallel, and can indeed be worked in no other way.

The engineer in charge of the station is Mr. J. E. Edgcome, A.M.I.M.E., A.M.I.E.E., who has been appointed to the position of borough electrical engineer. This gentleman represented, during the erection of the station, Mr. A. H. Preece, the consulting engineer to the Corporation. The buildings were erected by Messrs. Allen and Sons, of Kilburn, and the electrical equipment throughout was in the hands of Messrs. Siemens Bros. and Co., Limited,

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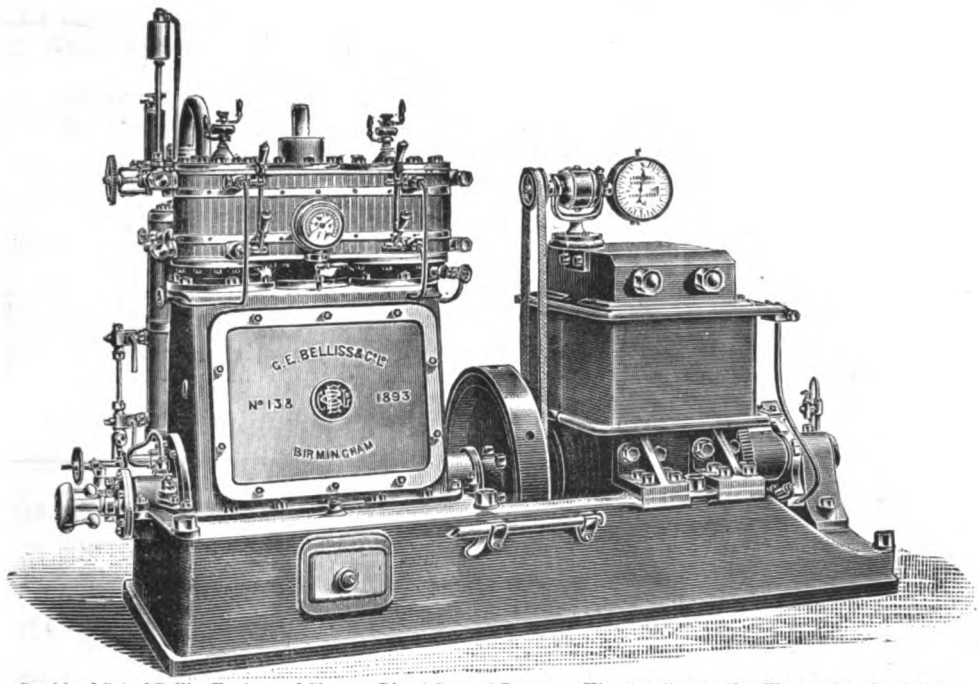
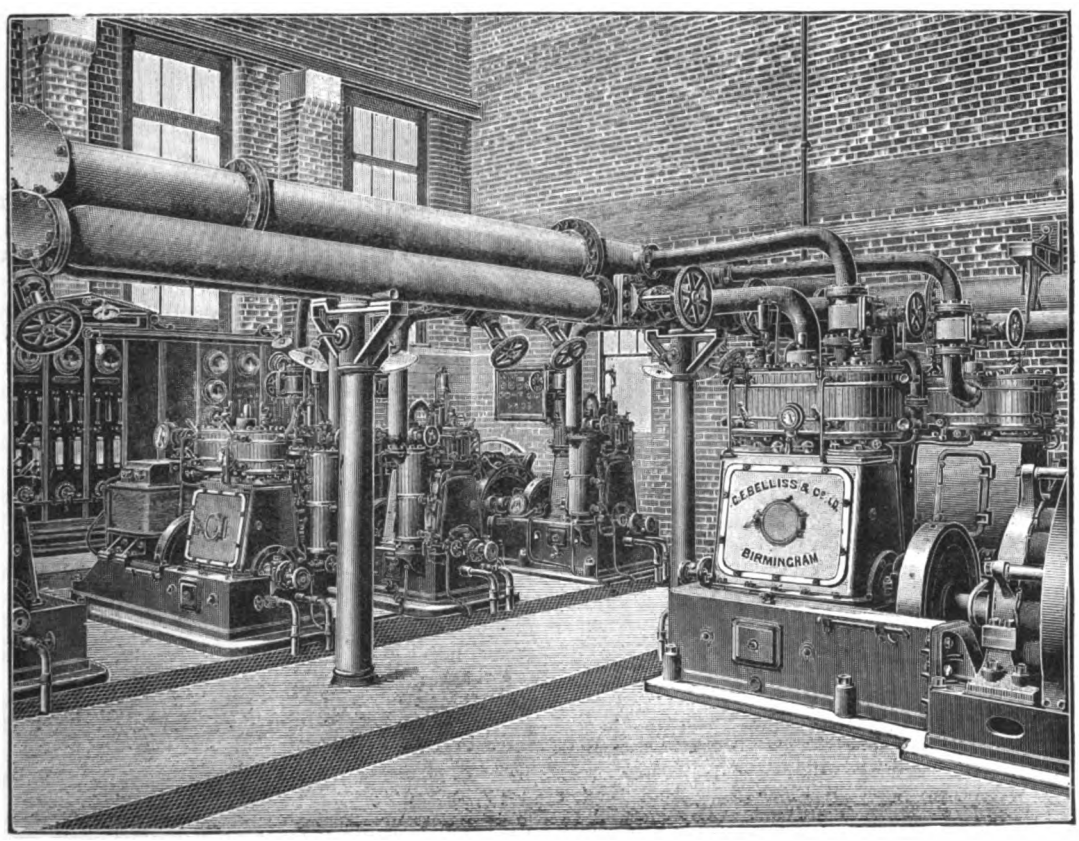
as contractors, to whom much credit is due, the generating and distributing plant having worked with satisfaction in all respects.

In the town of Kingston, of course the wiring of shops, houses, and public buildings, etc., has been in the hands of installation contractors—chief among whom may be mentioned Messrs. New and Mayne, of River Front, Kingston, who have put up about 500 incandescent lamps in various quarters, including the County Buildings, and the old-established Ceres Ironworks, Limited, of Kingston—who have also carried out a number of installations in shops, etc., involving several hundred lamps. The latter firm has, moreover, executed the order for arc lamp-posts required by the Corporation for street-lighting, their iron foundry department being capable of dealing with much heavier castings even than these. We illustrate the design and type of post adopted.



Combined Set of Belliss Engine and Siemens Direct-Current Dynamo—Kingston Corporation Electric Supply Station.



Interior of Engine Room—Kingston Corporation Electric Supply Station.

ELECTRIC LIGHT AND POWER.

BY ARTHUR F. GUY, ASSOC. MEM. INST. ELECTRICAL ENGINEERS.

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INSULATION.

(Continued from page 103.)

There seems to be no definite rule respecting the state of insulation resistance for electric light circuits, which is to be regretted. Each electric supply company requires a different standard, the same with the insurance companies; and there is a great variety in the way of expressing it, some requiring an insulation resistance a dozen times more than others, so that these rules are to a great degree very arbitrary. When treating of insulation resistance, it must be remembered that the greater part of the leakage is caused by the "fittings"—such as fuses,

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switches, lampholders, etc.; these harbour moisture, and so promote surface leakage: this is why it makes such a difference whether the insulation is tested on a dry or a wet day. The most general practical formula for insulation resistance is of the form—

Rule (I.) $$R_i = K \frac{E}{C},$$

where K is some constant the value of which differs according to different authorities; and whatever this value of K may be, the result is that the insulation resistance must, according to the above formula, be some function of the resistance of the conducting circuit.

With a fixed potential difference, E, the resistance of the circuit determines the useful current in the conductors, while the insulation resistance determines the leakage current; and, as the insulation resistance is K times the circuit resistance, hence $\frac{1}{K}$ measures the leakage current as the fractional part of the useful current. For example, let the pressure of the circuit be 110 volts and the current, say, 275 amperes, supplying about 500 lamps of 16 c.p.; then, if a numerical value of 10,000 be given to the constant K, we shall have—

$$R_i = \frac{10{,}000 \times 110}{275} = 4{,}000 \text{ ohms.}$$

Hence R_i, the insulation resistance, works out to 4,000 ohms, and as K has a value of 10,000, therefore the leakage current will be $\frac{1}{K} = \frac{1}{10000}$ part of the lamp current, or or in this case $\frac{275}{10000}$, or, roughly, $\frac{1}{40}$ of an ampere.

The above-mentioned formula is probably the simplest and most commendable to use, because it defines at once the ratio between the leakage current and the total current in practical work. If this is known, it tells us pretty well the condition of the insulation.

With regard to the value to be given to K, the value ranges from 5,000 to 50,000, or even 100,000. Instead of judging of the insulation resistance by its leakage current, it is a good rule to specify so many megohms as a constant and then to divide by the number of 16-c.p. lamps there are on the circuit. The rule then being

Rule (II.) $$R_i = K \div \text{lamps.}$$

The constant, K, in use amongst electric supply companies for 100-volt circuits varies from 100 to 10 megohms. For example, take a circuit at 100 volts, having, say, 1,000 lamps of 16 c.p. in parallel, and let the constant be 50 megohms, then the insulation resistance will be

$$R_i = 50{,}000{,}000 \div 1{,}000 = 50{,}000 \text{ ohms.}$$

Upon working out, this resistance will be found to correspond with a leakage current of $\frac{1}{300000}$ part of the total current.

Several of the leading electric supply companies adopt this rule, giving various values to K. Thus, the City of London require the high value of 75 megohms, the Bradford Corporation are satisfied with 10 megohms, while the Glasgow Corporation demand 60 megohms. Amongst those who prefer the first rule, that of stating the leakage current as a fractional part of the useful current, are several insurance companies, who have settled on $\frac{1}{200000}$ part of the current, while the theatre restrictions made by the London County Council allow a leakage of $\frac{1}{150000}$ part.

It is customary to double the constant when alternating currents are used, because the maximum value of the E.M.F. is higher than the working voltage, which, as before mentioned, is expressed by $\sqrt{\text{mean square}}$. A third rule is a mixture of the two previous ones, and consists in multiplying the constant K by the working voltage, whatever this may happen to be, and dividing by the number of lamps of 16 c.p. that are wired. This rule thus takes the form—

Rule (III.) $$R_i = K \frac{E}{N}.$$

Take a plant running, say, 4,000 lamps at 110 volts pressure, putting K as 80,000, we obtain

$$R_i = 80{,}000 \times \frac{110}{4{,}000} = 2{,}200 \text{ ohms.}$$

Tabulation 32 gives the insulation resistance worked out from Rule (I.) for various currents from 10 to 2,000, and also at various voltages, the standard for K being put at 50,000, so that the figures given are obtained from the formula $R_i = 50{,}000 \frac{E}{C}$, and thus show what the insulation resistance in each case should be, so that the leakage current will not exceed $\frac{1}{30000}$ part of the total current. This standard may be taken as one that will give most satisfactory insulation.

TABULATION 32.

Maximum current.	Working pressure of circuit in volts			
	110	80	65	50
10	550,000	400,000	325,000	25,000
30	183,330	133,330	108,330	8,330
60	91,700	65,000	54,166	4,166
100	55,000	40,000	32,500	2,500
200	27,500	20,000	16,250	1,250
400	13,750	10,000	8,125	625
600	9,100	6,500	5,416	416
800	7,000	4,000	4,621	312
1200	4,600	3,330	2,708	208
1600	3,400	2,500	2,310	156
2000	2,750	2,000	1,625	125

(To be continued.)

THEORY OF THE RESISTANCE OF A STRANDED CONDUCTOR.

BY W. H. EVERETT.

(Concluded from page 123.)

It was shown in the first part of this paper that the resistance of a stranded conductor may be regarded as consisting of the resistances of the different layers in parallel. We may return, then, to the case of a single layer, and it will be found more convenient generally to consider conductivity rather than resistance.

The conductivity of a layer when all its wires are insulated from one another, being taken as unity, its actual conductivity was proved to be

$$1 + \frac{4}{\pi} \cdot \frac{\rho}{r_1 + r_2} \tan^2 \alpha;$$

where ρ = specific resistance;
r_1 = contact-resistance per unit length;
r_2 = resistance across a wire between its two contact-surfaces per unit length;
α = angle between a wire and the direction of the axis of the helix.

In the above expression ρ and α may be supposed given, and we have now to see what we know about r_1 and r_2.

The contact-resistance depends, of course, on the area and nature of the surfaces in contact. If we make the supposition that the distortion at these surfaces remains similar when the gauge of the wire is varied, then the contact-resistance will vary inversely as the diameter of the wire. It is probably less important than the cross-resistance, which, on the same supposition, will be independent of the diameter of the wire.

This cross-resistance is the resistance between two narrow planes of unit length, approximately at opposite ends of a diametral plane of a cylindrical wire; or, taking a cross-section of the wire, between A B and C D (see Fig. 4). Let semi-circles be drawn on A B and C D, representing semi-cylinders in section; then if these semi-cylinders were equipotential surfaces, the whole resistance could be considered as made up of three resistances in series—namely, the resistance between these two surfaces and the resistance across two semi-cylinders. The actual resistance cannot be very different from this. Writing d for the diameter of the wire and $2b$ for the width of the surface of contact, the first-mentioned resistance can be shown to be $\frac{2\rho}{\pi} \log_e \frac{d}{b}$. The sum of the resistances of the two semi-cylinders is, roughly, $\frac{\rho}{2}$. Hence the total

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cross-resistance per unit length is approximately

$$\rho\left(\frac{2}{\pi}\log\frac{d}{b}+\tfrac{1}{2}\right).$$

Variation in the width of the contact-surface does not greatly affect the value of the cross-resistance, as is shown by the annexed table:

Diameter of wire / Width of contact	Cross-resistance (r_2). (Approx.)
5	2ρ
50	$3\frac{1}{2}\rho$
500	5ρ

Now the increase of conductivity owing to cross-current was proved to be

$$\frac{4}{\pi}\cdot\frac{\rho}{r_1+r_2}\tan^2\alpha.$$

Putting $r_1=0$, and $r_2=2\rho$, we find that the increase can hardly be greater than $\frac{2}{3}\tan^2\alpha$.

If the wires were straight, instead of being helical, the increase in conductivity would be $(\sec\alpha-1)$, or $\frac{1}{2}\tan^2\alpha$, α being small. Hence the conductivity of any layer would be nearly independent of α, and equal to that of a layer of straight wires, if

$$\frac{4}{\pi}\cdot\frac{\rho}{r_1+r_2}=\tfrac{1}{2};$$

that is, if $r_1+r_2=2{\cdot}6\,\rho$.

Assuming contact-resistance to be negligible, this would correspond to a width of contact-surface amounting to about one-twelfth of the diameter of a wire. This width is not likely to be exceeded in ordinary cables, and we should therefore expect that their resistance will be greater than if they were made of straight wires.

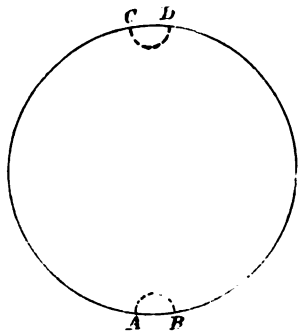

FIG. 4.

I am indebted to the Fowler-Waring Cables Company, the Silvertown India Rubber Company, and to Messrs. Siemens for information on the subject, and it would seem that the conductivity of a cable of n wires is not much less than the conductivity of n straight wires equal in length to the cable; corresponding to a width of contact amounting to perhaps $\frac{1}{50}$ or $\frac{1}{100}$ of the diameter of a wire. In the case of a layer for which $\alpha = 12\frac{1}{2}$deg., and therefore $\tan^2\alpha = {\cdot}05$, we should then get an increase of conductivity by cross-current of something like 2 per cent.

If the wires in a layer were compressed into a solid bar its conductivity would be $1+\tan^2\alpha$, the conductivity with insulated wires being taken as 1. For the length is decreased in the ratio $1/\sec\alpha$, and the area is increased in the ratio $\sec\alpha/1$. Hence the conductivity is increased in the ratio $\sec^2\alpha/1$. The increase is therefore $\tan^2\alpha$, or double what it is with straight wires.

We shall now obtain this result in an entirely different way, at the same time corroborating the fundamental expression for the increase of conductivity by cross-current. Suppose we have a layer of approximately square wires instead of round. The expression for the increase of conductivity in this case is easily found to be

$$\frac{\rho}{r_1+r_2}\tan^2\alpha,$$

where r_1 and r_2 relate to the square wires. The cross-resistance per unit length, r_2, now becomes equal to ρ. If the wires are compressed into a solid mass, r_1 becomes zero, and the expression becomes simply $\tan^2\alpha$, as before.

I had hoped to learn something more about the actual increase of conductivity by cross-current from an examination of the resistances given in cable-lists; but I find that they are practically useless for this special purpose, at least those I have so far seen. In some, the resistances are given only to two figures; in others, the resistances given would be, in many cases, too low if the weights of the conductors and the resistances and weights of the wires composing them are taken as accurate. Indeed, in the case of some cables the data are absolutely incompatible, for they lead to the result that the resistances of the cables are less than if the wires were compressed into solid bars of the same length and weight. This discrepancy is, perhaps, owing to the use in the cables of copper of higher conductivity than that on which the data for single wires are based. For our purpose it would almost be necessary to test single wires taken from actual cables, in order to obtain accurate data for comparison.

INSTITUTION OF ELECTRICAL ENGINEERS, Feb. 8.

Mr. ALEX. SIEMENS, President, in the chair.

At last night's meeting of the Institution the following candidates were balloted for:

Foreign Member.—Ernst Danielson, Allmänna Svenska Elektriska Aktiebolaget, Vesteras, Sweden.

Members.—The Marquis of Salisbury, K.G., F.R.S., &c., Hatfield House, Herts.; Benjamin Hillier Antill, Park House, Wallington, Surrey.

Associates.—Walter McLellan Arnot, City of London Lighting Company, Bankside, S.E.; Sidney Crouch, care of J. H. Holmes and Co., Oriel-chambers, Water-street, Liverpool; John R. Dobson, Brompton, Northallerton; Augustus Treyer Evans, 28, Bridge-street, Newport, Mon.; Oswin G. E. Hansom, Corporation Electric Light Works, Bristol; Alphonse Lucien Legros, 57, Brook-green, Hammersmith; J. Joseph Arthur Montealegre, 30, Queen's-gate-gardens, London; Percy W. Northey, the Richmond Electric Light and Power Company, Limited, Central Station, Richmond, Surrey; Henry Herbert Reynolds, Chesterfield, Hamilton-road, Ealing; William Gould Rhodes, Central Institution, Exhibition-road, S.W.; Charles Turner, Woking Electric Supply Company, Limited, Woking; Miles Walker, 102, Chetwynd-road, London, N.W.; James Whitcher, 14, Orde-Hall-street, Bloomsbury, W.C.

Students.—Frederic John Bakewell, 6, Gower-street, W.C.; Robert Birkett, Faraday House, Charing Cross-road, W.C.; Alfred Brown Blakey, 26, Dorothy-road, Clapham Junction, S.W.; Frank William Bowden, 9, Filey-avenue, Stamford Hill, N.; Alfred C. Eborall, 11, Queen's-road, Chelsea, S.W.; Edward Ernest Hoadley, Rochester-avenue, Rochester; George Reginald James Parkinson, Faraday House, Charing Cross-road, W.C.; John J. Pease, University College, Bristol; George H. Starr, 9, Halsey House, Red Lion-square, W.C.; Cecil L. Sumpter, 88, Netherwood-road, West Kensington Park, S.W.; Adolf Schoder, 121, Lansdowne-place, Brighton; Arthur Percy Strohmenger, 4, Tollington-place, Holloway, N; Frank Twyman, Victoria-road, Canterbury; Charles Yatman, University College, Bristol.

The following paper was then read:

SOME NOTES ON THE ELECTRIC LIGHTING OF THE CITY OF LONDON.

BY MAJOR-GENERAL WEBBER, R.E., C.B.

To the industry generally the history of the inception and of what led up to the accomplishment of the public lighting of the streets of that part of the Metropolis known as the City of London may have, for several reasons, a special interest and be worthy of record. By those who may not already know it, it should be understood that the Commissioners of Sewers hold a similar position and have similar powers to those that were possessed by the Metropolitan Board of Works and by the London vestries before the London County Council came into existence; in fact, they are the local authority, possessing jurisdiction distinct from that of the Corporation, the Common Council, the Bridge House Committee, and such bodies; having the direction and control of expenditure on works, for which purposes their engineer and surveyor is Mr. William Haywood, C.E., a gentleman distinguished no less as a colonel of Volunteers, late and for many years commanding the 1st London Rifle Volunteers,* than as an engineer.

I think there is a good deal in which the question of what led up to the lighting of the City by electricity so much differs from ordinary cases, that a slight sketch of its history—which has never, I believe, been published—is not out of place on the present occasion. The City is at the head of our municipal institutions, both as regards antiquity, wealth, and organisation. From an Imperial

* Colonel Haywood joined the corps in 1859 as a private, and rose through each rank to be lieutenant-colonel in 1876, and retired from that position in 1882.

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point of view it is regarded as the heart of the commerce of the world. In respect to public lighting by electricity, I believe I can show that it also has taken the lead. In 1878, when the municipality of Paris celebrated the international exhibition of that year by lighting the Avenue de l'Opera with Jablochkoff lamps, run with Gramme machines by the Société Générale d'Electricité, Mr. William Bassingham, deputy-chairman, and Colonel Haywood, engineer of the Commissioners of Sewers, severally reported to the Streets Committee in such detail, and in such terms, as to ensure the question never being dropped until the accomplishment of the results which we can nightly witness at the present time.*

It is nearly 15 years since the date of those reports—years that have been momentous to all of us electrical engineers. Colonel Haywood's report could not have dealt more exhaustively with the question, subject to the difference in knowledge at the present day, than if it was now to be compiled. He pointed out that no section of the Metropolis was more interested than the City in obtaining an efficient illuminant, for that within its boundaries the Gaslight and Coke Company then collected a rental of £370,000 per annum. No doubt that example of street-lighting in Paris induced the Commissioners to take up the subject. The 64 electric lamps in a thoroughfare 980 yards in length, placed 30 yards apart on alternate sides, were said to give a nominal candle-power of 20 times that of the 300 gas lamps previously used, allowing that one Jablochkoff candle gave 100 times as much light as a gas-burner using 12-candle gas at 5ft. an hour. The cost price of these lamps (estimated then at 6d. an hour, as they were extinguished at midnight) was £50 a year each, which, for 64 lamps, came to £3,200 a year, as against the cost of the gas lighting during the same hours, which came to £1,200 a year at five centimes per gas lamp an hour. Colonel Haywood at that time considered that the avenue was lighted "vastly in excess of all reasonable requirements"; and although he went no further than stating that in his opinion there were places in the City—such as by King William's Statue, in front of the Mansion House, and in the circuses—where the convenience of the large traffic "might justify the expense of employing the electric light during the busiest hours of darkness," he nevertheless recommended the Commissioners, "that as early as possible an ample experiment be made by lighting with electricity during the winter months of 1878 one or more of the public thoroughfares within their jurisdiction." In consequence, in November, 1878, the same company commenced lighting the Holborn-viaduct with 16 Jablochkoff lamps, placed about 110ft. apart. They were run from sunset till midnight, replacing 86 gas lamps.†

The results arrived at after three winter months' work were that, while only doubling the light (allowing a loss of 50 per cent. with the globes) of the 86 gas lamps, the cost—namely, 5·73d. per hour—of 16 Jablochkoff lamps was four times that of gas at ½d. an hour. The discouragement produced by this experiment only continued for one year, and in the spring of 1880 the Commissioners (at the instigation of several members whose names have since been connected with improvements in lighting the City) again decided to renew experiments on a more extended scale by lighting (see streets shaded black on map, Plan No. 1) New Bridge-street, Queen Victoria-street, Queen-street and Queen-street-place, King William-street to the Bank, Poultry, Cheapside, St. Paul's-churchyard, Ludgate-hill, New Bridge-street, and the bridge. The thoroughfares in which the trials were to be made were divided into three districts, and out of six competitors who tendered in October, 1880, the following were selected, and the year's work lasted from April 1, 1881, to April 1, 1882: The Blackfriars Bridge district to the Brush Company; the Southwark Bridge district to the Electric Light Power Generator Company (Lontin system); the London Bridge district to Messrs. Siemens. Colonel Haywood reported in June, 1882, that, allowing 50 per cent. of loss through the use of globes in the several districts, the increased light afforded and the cost of the same under the tenders, in proportion to the gas, were:

	Increased light.	Relative cost.
No. 1 (Brush)	15	About the same.
No. 2 (Lontin)	14	Twice.
No. 3 (Siemens)	13½	3½.

Thus the City of London has taken the lead in making a practical experiment on a large scale.‡

The encouragement afforded by the results may be estimated by the following: (*a*) The Commissioners decided to experiment again in four additional areas and, calling for tenders, received, in May, 1882, offers from eight firms. In one tender only was the question raised of supplying light for private consumption. (*b*) Messrs. Siemens's offer to continue lighting No. 3 district at £3,600 a year, being an advance of £1,330 on their original contract, was declined, and that firm retired from the City. (*c*) An arrangement with the Brush Company to continue for another year lighting No. 3 district at a cost of £800 per annum was made.

But, as we all know, the Electric Lighting Act of 1882, which obtained the Royal consent and became law in that year appeared, and with it a flood of applications for provisional orders and licenses, three of which covered the area of the City, and obliged the Commissioners to hold their hands and consider the position in which the Act placed them, after having already had the subject in hand for nearly four years. In November, 1882, the Streets Committee of the Commissioners of Sewers consulted Mr. Preece, and I shall take this opportunity to remind him of a statement he then made, and has since repeated on the subject, in which, I am happy to be able to say, he showed an accuracy of foresight in which later experience has fully supported him. At that date he wrote: "I know of no branch of engineering where more forethought is necessary to calculate all the contingencies likely to be met with than a system designed to illuminate a large city like that of London." Meantime, an experiment with public lighting by incandescent lamps had been in progress. In April, 1882, the Edison Company commenced an experiment with that means of illumination on the Holborn-viaduct for a length of 466 yards, upon which Colonel Haywood reported after a 12 months' run. Ninety-two 16-c.p. incandescent lamps replaced the gas-burners in the existing street lanterns, 86 14-c.p. gas batswing burners being displaced. The result in light and cost was that the electric lighting contractors gave 1¼ times the light at the same price as gas—namely, £4. 10s. 4d. per burner per annum. That this experiment led to but negative results we all know. If it showed anything, it was that the substitution of an incandescent lamp in the ordinary street lantern for the lambent flame of a gas jet, so that the incandescent filament is directly visible, is a very poor and unintelligent application of the electric light, and puts it in a position in which it is at a great disadvantage in comparison with gas. I believe that the incandescent lamp for public lighting purposes never quite recovered from the results of that experiment. The City was one of the earliest areas upon which the electric light manufacturing companies set their eyes. Hardly had the 1882 Act become law when, as I have said, three companies commenced applications for provisional orders. As still now occurs, the local authority took alarm, and began to investigate the subject for themselves. Most complete reports as to the law, engineering, and science of the question were made by Mr. Baylis, Colonel Haywood, and Mr. Preece. These gentlemen may be said to have been amongst the very first to compile information for a local authority on the subject of electric lighting; and, although 10 years have passed, the terms they used, conclusions arrived at, and recommendations made, differ very little from those that have since and up to this date been, and are being, laid before similar governing bodies for their information and guidance.

The general tenor of the recommendations made in 1883, especially by Mr. Preece, were that the Commissioners ought to obtain their own provisional order or license and, either by contractors or by their own officers, to carry out the undertaking for themselves, both for public or private supply. The consequence was that in March, 1883, the Commissioners decided to apply to the Board of Trade for the necessary license, under the Act of 1882, for the whole city having in its terms a compulsory area of a limited size, and to oppose all other applications for provisional orders or licenses under the Act of 1882. Although tenders from a number of electric light manufacturing companies were called for and received, it is of moment to note that Mr. Preece reported that their terms were all "eminently unsatisfactory." No doubt his criticisms were correct, but as the length of time of the proposed contract was limited to seven years, it is not surprising that they were not such as could be accepted. The lowest and highest offers for each public light arc lamp were £36 and £71 per annum respectively. In spite of amendments in those proposals, Mr. Preece could still find nothing to recommend them; but we, who look back to what has transpired in the interval, can realise that all proposals made in those days, when the security offered was such that capital recoiled from it, were necessarily wild and unsatisfactory, and were mostly made by firms who, if they were sound, must have secretly hoped never to be called on to carry them out. Meantime, the Anglo-American Brush contract for lighting, for about 4,030 hours per annum, New Bridge-street, Ludgate-hill, and St. Paul's-churchyard still ran on, and was costing the City at a rate of less than £25 a lamp. Then, in 1883, commenced a period during which companies proposing to obtain statutory powers within the City were kept at arm's length, and during which Mr. Preece, instructed by the Commissioners, made experiments on the subject of public lighting by arc and incandescent lamps, partly with the aid of the Anglo-American Brush and Edison contract installations then running. In 1883 he reported "that, while the arc lamp is admirably adapted for the illumination of large spaces, the incandescent lamp is eminently adapted for our streets and narrow thoroughfares." Mr. Preece's report to the Commissioners of Sewers, of August, 1884, while being very exhaustive as to the whole question of electricity supply generally, is certainly also the standard report on the subject of public lighting. He then stated, however, that "the lamp which, in my judgment, best lends itself to street-lighting is the glow lamp, and of the glow lamps I prefer the 50-c.p. lamp for the main thoroughfare." Notwithstanding the Holborn experiments, Mr. Preece recommended further trials of public lighting with incandescent lamps, combined with a means of distribution for private lighting within a small area that would require about 5,000 private lamps, at a cost to the city of about £40,000. He also brought very prominently to notice the very valuable proposals of Mr. Trotter connected with his dioptric lantern, to which I shall myself allude later on. These further experiments were never carried out, but I think the meeting will be glad to hear from Mr. Preece if any modifications would now be admitted into his views on a subject which the meeting is aware is not yet satisfactorily settled.

* As international juror for telegraphs and allied electrical applications of that year, my notes on the installation show that the Avenue and Place de l'Opera, and the Place du Théâtre Français, only represented a small fraction of the application of the Jablochkoff lamp then running in France.

† At the same time the Metropolitan Board of Works had been making experiments with the same company's plant on the Victoria-embankment, including photometric comparison of the gas and electric light.

‡ It was estimated to cost over £8,000, but, through the inability of the contractors in No. 2 to commence lighting in time, and for other reasons, it actually cost about £5,400.

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For more than a year the subject slept.* At that time it fell to my lot to be placed in engineering management of the Anglo-American Brush Electric Light Corporation, and since then, up to July, 1892, I was intimately acquainted with all that has gone on connected with the lighting of the City of London.† The original contract of 1881 of that company for lighting New Bridge-street, Ludgate-hill, and St. Paul's-churchyard with arc lamps still ran; but there were many outward signs of considerable repairs being necessary in the mains. These mains had been laid into the district under the roadways from the Brush Works in Belvedere-road along Bankside, and over Blackfriars Bridge, and they consisted of two circuits of 7/16's drawn into the same cast-iron pipes, with insufficient draw-boxes and means of inspection; although the insulation was sound throughout the greater portion of their length, there were many points at which it had been attacked by the pipes having been hastily laid where they were exposed to soil saturated by sewage liquids and other gases and with insufficient means of access for localisation and removal of faults. The currents were generated by Brush arc dynamos, old-pattern armatures, having belt gearing to engines, which, with the boilers, formed part of the power which was used in the Brush factory, on which the demands were irregular and occasionally very heavy. The fact was that the Brush Company, when they tendered for the work in 1881, understood it was to be an experiment, out of which little or no actual profit could be expected, and little thought that arrangements which would have been good enough for 12 months would be continued by the City authorities for five years, only terminating through the initiative of the Brush Company and by the permission of the Commissioners in December, 1885.

No public body has probably taken more pains than the Commissioners to weigh carefully the *pros* and *cons.* bearing on the question of their becoming themselves the undertakers for supplying electricity‡; and I think now that but for the host of offers, merely speculative and otherwise, which was being continually sent in to them and diverting their attention from the issues most in the interests of the ratepayers, they would in the end have decided on raising the necessary capital to do the work themselves. In November, 1885, a set of proposals was formally made by the Brush Company to contract for the public and private supply of a district of the City, and this was considered by a committee of which Mr. J. C. Bell was chairman. This was the first practical arrangement on a large scale that had ever come before the Commissioners, and its terms are almost *verbatim* those that were eventually adopted in January, 1889, as the conditions under which the Commissioners would receive tenders. From that moment the question of the lighting the City made a fresh start on a tangible basis as to cost and mutual advantages; and although it took five years to mature, there was no longer any serious question of the Commissioners themselves becoming the undertakers. In 1886, 1887, and 1888 the matter was again from time to time before them, and throughout that time it was due to the personal exertions of some enlightened members of the Streets Committee that the matter was kept continually to the front.§ One of the reasons for the delay was due to a great reluctance on the part of the Commissioners to permit any company to have a provisional order within its area of control. The chief reason for this was the condition of things at and below the surface. The occupation of the subsoil by sewers and subways, by the systems of gas, water, and telegraphs, and by various other objects, is entirely exceptional. They would have much preferred that all powers for the disturbance of the surface should be conferred by themselves only, and not by statute. There is no doubt that the ratepayers of the City would now be in quite as good a position if no provisional orders had been granted, and if only the contracts that were eventually entered into between the Commissioners on the one part, and the Brush Company and Messrs. Laing, Wharton, and Down on the other, were existent. Owing to more than the ordinary rights of user of the soil of thoroughfares and streets being vested in the City Corporation, statutory powers were not necessary to enable them to grant way-leave.‖ In February, 1888, the Commissioners called for a report giving a *résumé* of all that had been brought before them in the previous 10 years; and I must here say that it fully establishes the claim of the Brush Company that a large share of the credit for the eventual results was due to their persistence in holding the ground when all others had retired, and in keeping the subject always before the local authority in a manner and in terms which by their moderation and practical sense were bound in the long run to commend themselves to business people. The object of this report was to show that the successful use of arc lamps for illuminating large spaces had asserted itself all over the civilised world.* The advantage of having a contract with a company to supply current to public arc lamps at 3·1d. per unit, including trimming and carbons, instead of at 8d. exclusive of the same—the usual price in provisional orders—was dwelt on. The unsatisfactory nature of the proposals made to the City by other parties was fully exposed. The great advantage to the City of the terms of the form of contract originally proposed by the Brush Company in 1885 were adopted, and the misrepresentations which suggested monopoly that had been made were dispelled; and it is a remarkable fact that the then proposed charge of 1s. per unit for private lighting was not considered excessive in view of the circumstances of the probable demand for business premises in the City. January, 1889, found the Commissioners, again, and finally, roused to activity by the Electric Lighting Act of 1888 (due to the personal exertion of Lord Thurlow, the chairman of the Brush Company), and, the City being divided into three districts for the purpose of the contracts, tenders were publicly called for; and it may here be remarked that the company which during eight years had done so much to keep the matter before the public, at that moment was in no better position in March, 1889, as regards tendering, than any other firm which was then only dealing with the matter for the first time.†

But yet another stage of opposition had to be got over before the final arrangements for this great undertaking could be said to be on a satisfactory footing. Major Marindin, in April, 1889, had reported against the claim of the City to be exempted from the operation of the Electric Lighting Act, and had, in face of the opposition of the City, recommended the approval by the Board of Trade of the applications for provisional orders from two of the above-named companies. The Brush Company had for several years, in deference to the views held by the City authorities, refrained from making applications for orders, and therefore their absence from the list of applicants in 1889 was intelligible. In the terms of Mr. Preece's report on Major Mandarin's contention, the City had been "regarded merely as a local vestry with some ancient rights that have to be respected;" and that "the amount of lighting and the capital necessary to be expended in the City, which far exceeds that for any other portion of the Metropolis," had been overlooked. Major Marindin by his recommendation had neglected not only the geographical part of the question, but the fact that the Commissioners of Sewers had been for years studying and experimenting on the question of effective public street-lighting. The tenders for public lighting the main thoroughfares with arc lamps which eventually were reported on, in November, 1889, by Mr. Preece and Colonel Haywood, were the Metropolitan Electric Supply Company's revised tender to light the western district with 121 lamps, at £26, £3,146; the Anglo-American Brush, the central district with 138 lamps, at £26, £3,588; the London Electric Supply Corporation, with 136 lamps (half the lamps being extinguished at midnight), at £24. 2s., £3,290—total for the main thoroughfares, £10,024; and the acceptance of these was recommended. But of them the Brush Company alone (consistent with their original proposal) had not applied in 1889 for a provisional order, and had agreed to the division of profits under a sliding-scale—namely, that if the profits exceeded a cumulative dividend of 10 per cent. per annum upon the capital invested, the excess was to be divided equally between the contractor and the consumer—and also had agreed that power should be reserved to the Commissioners to acquire the undertaking and works by purchase at the end of 21 years, in all other respects in accordance with Section 2 of the Electric Lighting Act of 1888

Meantime, no provisional orders had been granted for any part of the City area, owing to the withholding of the usual recommendations from the local authority which the Act requires. But on the last day of June of that year the Brush and the Laing, Wharton, and Down Companies gave notices for the western and central and the eastern districts, respectively, and the ordinary statutory steps followed in due course. The Brush Company had, as stated, accepted the terms of the Commissioners' contract, and the Laing, Wharton, and Down Company now decided to fall into line with them;‡ and in May, 1890, those contracts were sealed, and the provisional orders became law in that session of Parliament.§ Not until 1891 were a similar contract and provisional order granted to the Brush Company for the western district. Thus, after nearly 13 years of deliberation on the subject, the scheme for supplying electricity to the City of London for public and private consumption became legally possible, and all the special powers which the Commissioners sought to obtain in the interests of their ratepayers had been secured.

(To be continued.)

* In November, 1885, a well-known writer reported to the Commissioners: "At the present time there is a complete stagnation in electrical enterprise in England, in such enterprise as would undertake the supply of electricity upon a large scale for public and private purposes in towns."

† My own connection with the public lighting of the City of London dates back to the sixties, when I assisted the late Dr. Letheby, city analyst, in a series of experiments connected with carburetting gas for street lamps.

‡ So late as April, 1890, they deputed Mr. Preece to report to them on the electric lighting of the public streets of Taunton with arc and incandescent lamps.

§ Mr. Frank Green, Mr. J. C. Bell, Mr. Graham King, Mr. Bridgeman, Mr. Pannell, and others.

‖ There is ample experience to show that if much of the Act of 1882 had been repealed, so far as the Metropolis was concerned, as was more than once urged on the Board of Trade, this and many geographical and other anomalies which have kept up, and will for many years keep up, the price of electricity in London, might have been avoided.

* The successful lighting on a large scale by the Brush Company of the Colonial, Manchester, and Glasgow Exhibitions was described.

† The contractors who tendered were the (1) central, Anglo-American Brush Corporation; (2) London, London Electric Supply Corporation; (3) west, Metropolitan Electric Supply Company; (4) all, House-to-House Electric Supply Company; (5) east, Messrs. Laing, Wharton, and Down.

‡ The Commissioners had required Mr. Preece to report fully on the Thomson-Houston system of arc lighting as established at Sheffield and the St. Pancras Station, as well as at Taunton.

§ The names of Mr. E. Garcke and of Mr. Sydney Morse are so well known in connection with the industry, that it is appropriate to record here that to them is largely due the credit for carrying through final arrangements for these orders, which were exceptionally intricate in their character.

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THE
ELECTRICAL ENGINEER.

Published every Friday.
Price Threepence; Post Free, Threepence Halfpenny.

Editorial and Publishing Offices:
39-140, SALISBURY COURT, FLEET STREET, LONDON, E.C.

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TO CORRESPONDENTS.

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TENDERS AND TENDERING.

The peculiar condition of affairs at Newport, coming on the top of a warm discussion relating to matters at Coventry, will perhaps do more to open the eyes of local authorities to certain consulting engineers' practices than any amount of cogent criticism without such revelations. Let us examine for a moment the general object to be gained in obtaining tenders; but, first, a few words relating to consulting engineers, taking it that such persons are employed. The consulting engineer is *supposed to be* unconnected with any of the tendering firms; he is supposed to be an expert who, for a certain remuneration, will give his whole and undivided services to the preparing of plans and to the proper advising of his employers. If he is inexpert, or if he is in any way connected with tendering firms, or if he induces his employers to believe in him by appeal to seemingly unbiassed authorities when at the same time those authorities—journalistic or otherwise—are in his pay and under his control, then something altogether foreign to old-fashioned consulting practice must be looked for. Perhaps, however, we must look upon the consulting engineers of the *fin-de-siècle* order as commencing a new departure which older fogies do not at present countenance, but which may in the long run prevail over the old order of things. The consulting engineer, then, supposed to be an expert and to know his business from beginning to end, prepares his plans and specifications—for what? Usually we take the desire to be to get those plans carried out according to those specifications at the smallest cost to his employers. If the plans are carried out according to the specifications—and it is the engineer's duty to see that this is done without fear or favour—we must emphatically and deliberately maintain that he is not justified in recommending any except the lowest tender. Thus, we contend, the consulting engineer at Newport is going altogether outside his duties, and is not acting fairly to his employers, in recommending contractors whose tenders will cost more than the lowest tender. The—shall we term it—waiver clause in most advertisements, to the effect that the authority does not bind itself to accept the lowest or any tender—is a clause usually inserted, and properly so, for quite another purpose than whitewashing wrong actions of any authority. There are often tenders sent in manifestly of no *bonâ fide* character, and from firms who have another object than that of getting the contract in view, and it may be that obviously fatal errors have been committed in the figures of which no well-meaning authority could take advantage. Putting aside those tenders sent in *malâ fides*, and those obviously incorrect, there is absolutely no moral, legal, or commercial argument for accepting any but the lowest tender. If such other should be accepted or recommended the procedure savours of favouritism, a thing which is not recognised in commercial practice when tenders are concerned. The consulting engineer has also his privileges and his duties towards contracting firms, and if he is thought to persistently favour one or some above others, the

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inevitable result arises that firms of repute, firms of the highest standing will have nothing to do with him or his works; hence he cannot give what his employers want. The course of proceedings at Newport is, to say the least, unsatisfactory. There is, so far as we are aware, no suggestion that the consulting engineer prefers incompetent to competent contractors; the only question in dispute is the choice between two competent firms, one of which tenders lower than the other. The only reason so far assigned for the selection of the higher tender is that the firm sending in the lower tender has had less experience in a certain direction than the other, and is by some people looked upon as a firm wedded to an opposite system. To our minds, such an argument, if true, is not worth the value of a farthing rushlight; but in this case it is not true. The firm referred to is the oldest—or almost the oldest—in the trade, has had far more experience than the firm selected, and has always denied being tied to any one system, arguing that in every case the system to be used must be adopted to the circumstances under which it has been used. In this article we have dealt more with the abstract question of tenders rather than with the concrete example, using the latter only as a peg to hang a sermon upon. The other questions that might and perhaps will have to be considered are the competency or incompetency of the engineer as shown by his works, and the methods, journalistic and otherwise, used to obtain the confidence of local authorities. History does not often err in its lessons, but history may be misrepresented and conclusions drawn therefrom which are incorrect. We shall await the further development of the Newport matter with some interest, and trust that at the eleventh hour the *fin-de-siècle* methods may give place to the old sturdy views—to do what is right, and care for nobody.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

NAME OF FIRM.

SIR,—Owing to the numerous enquiries we have had recently as to whether we have changed the constitution and address of our firm, we feel it incumbent on us to state that there has been no change whatever, and that the partners, F. H. Nalder, H. Nalder, C. W. S. Crawley, and A. Soames, who have conducted the business during the last six years, still carry it on as Nalder Bros. and Co., and that our sole place of business is at 16, Red Lion-street, Clerkenwell, London, E.C., as heretofore.—Yours, etc.,

NALDER BROS. AND CO.

AIR-CORE TRANSFORMERS.

Messrs. Frederick Bedell and Albert C. Crehore write as follows: In a paper on "The Behaviour of an Air-Core Transformer when the Frequency is Below a Certain Critical Value," read before the Physical Society, October 27, 1893, Mr. E. C. Rimington has called attention to the case in which the primary current of a transformer falls off when the secondary is closed. This phenomenon was noted by us last spring, and attention called to it in the *Electrical World*, June 17, 1893, in Article V., on the "Theory of the Transformer," where a curve is drawn, Fig. 14, showing the value of the primary current for different loads. We have not yet seen the full text of Mr. Rimington's paper, but from various references to it would infer that much of the same ground has been covered by him as was given by us in a paper before the Electrical Congress in Chicago last August, entitled "General Discussion of the Current-Flow in Two Mutually-Related Circuits Contained Capacity," printed in full in the *Physical Review* for September-October, 1893. In a more recent communication, Mr. Rimington calls attention to the fact that Mr. Kennelly, in an article entitled "The Impedance of Mutually Inductive Circuits," in the *Electrical World* for October 21, covered some of the same ground as given by him in his paper before the Physical Society above referred to. In a geometrical treatment of the same subject, "Theory of the Transformer—VIII.," *Electrical World*, November 25, we showed the identity between analytical and graphic methods of solution, including that of Mr. Kennelly, and showed that the whole is derivable from the results given in the paper above referred to, presented by us before the Electrical Congress.

This decrease in the primary current of the transformer as the load increases, where the constants of the transformer have certain particular values, is certainly an interesting one, although the amount of increase would always be small. Although the transformer has been the subject of a great deal of discussion, and its theory has been approached from all sides, and the instrument experimented upon by many different methods, it is still a fruitful source of study to the theorist and experimenter, and there is still room for the discovery of many facts interesting and unique.

January 30, 1894.

THE UNDERGROUND ELECTRIC LIGHT MAINS IN THE CITY OF GLASGOW.*

BY WILLIAM LACKIE.

Although this paper is put down as one on "Underground Electric Light Mains," I do not intend going into the subject generally, but rather to give a short description of the electric light mains laid down in Glasgow, and the work connected with them.

In the beginning of August, 1892, the Corporation here engaged a contractor to lay down mains, to supply electricity to private consumers on what is known as a low-pressure three-wire system. The three-wire system consists of two dynamos, or sources of electric current, connected together in series, and three wires taken from them, one from each outer terminal, and one from the connecting point. The current generated in No. 1 dynamo and raised to a potential, or pressure, of 100 volts, might be said to pass into No. 2 dynamo, where it is raised another 100 volts, so that between the two outer terminals we have a difference of potential of 200 volts, and between either of the outer two and the middle wire 100 volts.

At present there are lights equivalent to 20,000 8-c.p lamps between the positive and middle, and an approximately equal number between the middle and negative. All the current that goes out from or comes back to the station along the middle wire is what is necessary to light the difference in number of lamps lit between the positive and middle, and the middle and negative. This is generally very small, and never should be over 200 amperes.

The generating station has been erected at the south-east corner of Waterloo-street and Mains-street, and mains are laid eastwards along Waterloo-street to the city, and up Mains-street to Sauchiehall-street. The arrangement of the dynamos here is a slight modification of the simple three-wire system. There are nine dynamos in all, but only two of these, and two sets of storage batteries of 57 cells, are joined in series, and the middle wire is taken from the connecting point between them. The remaining seven dynamos give out their current direct at 200 volts, and have no middle-wire connection. The two dynamos which are joined in series are called the "balancing machines," and

* Paper read before the Physical Society of Glasgow University.

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they, along with the batteries, supply whatever current is required along the middle wire.

You will see that with this arrangement there is only half the number of machines to look after; also, there is a saving in mains, as you have two mains in place of three, which would be required if all the machines were 100-volt machines joined in series for the main supply. The mains off which consumers get their supply consist of three wires — positive, middle or neutral, and negative. Lamps connected between the positive and middle are said to be on the positive side; and lamps connected between the middle and negative, on the negative side of the system.

Originally it was thought that all the mains might be laid down on a system of bare copper strip, supported on insulators, placed in cast-iron troughs, bolted together and laid under the pavement. However, on examining the principal streets, it was found that there were so many cellars below the pavement, with the arch of the cellar close up to the flagstones, there was no room for the troughing, so a combined system of bare strip and insulated cables in pipes has been laid down. The sole reason that troughs and bare strip were not laid in all the streets was that in some streets cellars ran the whole length of the street, and in others cellars only here and there, which meant far too many manholes; for, where troughing stops and pipes begin, a manhole has to be built to allow the jointing of the copper strip to the insulated cable. These troughs consist of cast-iron boxes of the shape shown in the drawing. They are cast in two sizes, called "three-way" and "five-way." They are both 4ft. 6in. long and 7in. deep, but the three-way is 18in. broad and the five-way 21in. broad. To lay the troughs the pavement is removed for a distance of about 40 yards, which is the length that a squad of about 15 men can do comfortably in a day. A trench is then dug, 18in. deep, and rather broader than the outside size of the troughing to be laid, as the troughs have to be bolted together from the outside. The troughs are then laid into the trench on fairly and truly bedded ground, and levelled transversely, but they have always a sufficient slope to drain into a manhole which is placed at the end of the length. The streets of Glasgow lend themselves very well to this, as most of them have a natural slope. The troughs fit one into the other, and are jointed with red-lead putty, and securely bolted together with two bolts, one on each side. The whole length of troughing is laid first, and then cleanly swept, and the insulators and tiles put in in their proper places—*i.e.*, one insulator at the beginning of each trough, and two tiles equally spaced between them. Snugs are cast in the trough to hold the insulators and tiles in their proper position. The insulator supports the copper strip, and the tiles will, should the copper strip sag, prevent it touching the bottom of the trough. Both insulator and tile are arched on the bottom so as to allow a free flow of water, should any find its way into the trough.

The requisite number of copper strips is now pulled in and placed in the grooves of the insulators. All the copper strip laid is of the same size—namely, 1in. broad by ¼in. thick. If a larger main than this is required, two or more such strips are pulled in and laid flat one on top of the other. When the requisite number of copper strips has been laid in they are gripped together at one end in an iron grip-box (shown), and at the other end a lever is applied to each strip, one at a time, and stretched until each strip is perfectly straight. Not only does this stretching straighten the copper, but as the first trough is used as a stay at one end, and the last as a heel for the lever at the other, it has the effect of pressing all the troughs firmly together, and allowing them to be more tightly bolted together. Red-lead putty is now laid in a groove along the edge of the troughing and the covers laid on carefully. The ground can now be filled in and the pavement replaced.

At the end of each length of this troughing a space of about 2ft. is left, before starting another length, for a manhole to be built. A manhole consists of four brick walls built in a square of about 2ft. or more. The bottom of the manhole is always 15in. clear below the lowest way, troughing or pipes leading into it. It has a square iron frame laid on top of the brickwork, with a U-shaped projection on its inner edge for carrying the manhole cover, which consists of an iron framework or box filled in with concrete. This frame or box has two rectangular notches in two opposite sides for the purpose of lifting it, with two suitable handles when desired. The cover fits into the frame, and is jointed with red-lead putty and yarn.

The troughing has never been laid below the roadway, as it would not have been safe, owing to the great weight it might be called upon to carry, and also in case of subsidence, such as we have had too often of late, which might cause serious damage and inconvenience. Across the roadways, cast-iron pipes are laid, varying in size from 2in. to 6in., so that at the corner of most streets you will see a manhole, where the troughing stops and pipes begin. Insulated cables are pulled into those pipes, and tinned copper thimbles soldered on to the ends, and then the copper strip and cable are clamped together in a gunmetal grip-box. Should the copper strip expand, the insulated cables are flexible enough to give a little in the manhole. In long lengths of copper strip we have tried expansion joints in an intermediate manhole, but I do not know if they are ever called upon to work. This system of gripping the copper strip and cable together is perfectly good for the theoretical resistance of a main, and the measured agree to within 2 per cent.

This whole system of underground mains is simple, and, as far as I have seen, very good. A piece of ground can be opened in the morning, and the mains laid and closed again by night. Had concrete culverts been used, they would, in Glasgow, have been more expensive, and the ground would have required to be open for three or four days. I know that the patience of the merchants and general public was severely taxed even with the one day's turn-up. I have heard it said that those troughs were not absolutely watertight. They are not, but are not very far from it. However, I see no very serious danger arising from this. The pavement over them is always laid firm and on a slope towards the gutter, and keeps the ground below almost perfectly dry. A great many of our troughs are laid below granolithic and asphalte, and are therefore watertight so far as rain and snow are concerned. Should water find its way into the troughs, it will immediately flow down to the nearest manhole, where it drains away naturally; or if it does not, a drain is laid from it to the nearest sewer. So long as the lowest manhole in a district is well drained, I think there is little chance of our mains being flooded, for should it rise in one manhole, it will immediately flow either by way of the pipes alongside the troughing (to which I will refer immediately), or along the troughing itself until it reaches the lowest manhole. Alongside most of the troughing two pipes are laid—one for carrying the cables for the street arc lighting, which is on a different system to that of the private supply, and the other for carrying potential or test wires, which run back from various parts of the city to the station for the purpose of testing the potential at those points.

The supply mains, or network of the city, therefore practically consist of three copper mains each ¼ square inch area, either in the form of bare strip or insulated cable, and are painted in the manholes—the positive, blue; middle, white; and the negative, red. Not long ago, it was the habit to paint the positive red and the negative blue, but I believe that since Wilkes's pole-finding paper (which turns red at the negative pole on passing a current over it) has come into use so much, the colouring of the positive and negative has been reversed. Had strip been laid everywhere, there would have been no necessity to colour them, as a rule—that the positive must be laid next the building, or always to the north or west side of the troughing—could have been adopted.

The middle wire leaving the station is connected on to the network or supply mains at the point nearest to the station, but the positive and negative wires are not. There are a number of positive wires and an equal number of negatives, called "feeders," which leave the station and carry the current out into the city, and are joined on to the network at nine different points, called "feeding points."

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It is from those feeding points that the potential or test wires are carried back to the station, and the pressure of the current is varied in the station so as to keep the difference of potential between the middle and positive or negative a hundred volts. You will see that, since the feeders have to carry the total current sent out from the station, they must be of a greater area than the network. The area of the feeders varies, according to their length and the district they are likely to supply, from ½ square inch to 1 square inch.

In a water supply there is always a certain amount of pressure lost between the pumping station and the point at which it is delivered; so in this electricity supply, although the current is sent out at a pressure of 230 volts, we may only have 200 volts at those feeding points when there is a current of 6,000 or 7,000 amperes going out. If a small current of 400 or 500 amperes is going out, the fall may only be two volts. The fall of potential along a wire varies directly as its length and current flowing along it. The feeders, therefore, should be of such a length and area that the fall along each is the same, in order that they may take their supply from the omnibus bar of the switch-board, which is, as the word indicates, the bar to which all the dynamos are connected.

At the beginning of any station it would be very difficult to make them of the proper area. The length is practically fixed by the district or streets to be supplied, but no one knows what the current along each feeder is to be. Once the station has been running for some time you can easily, by pulling in either larger or more cables across the roadway, or by pulling in an extra copper strip, make your feeders such that the fall along each is the same to their respective feeding points. If a specially heavy load comes on in any one district, and the feeder to it is called upon to carry more than its usual load, it is a very simple matter for the night or two to connect a dynamo giving its current at a higher voltage on to that feeder.

The feeders, when laid in cast-iron troughs, consist of three or four of the ¼ square inch copper strips placed one on the top of the other. When iron troughs are not used the feeders take the form either of an insulated cable pulled into a pipe, or of a steel-armoured cable made by Siemens and Silvertown. This armoured cable consists of an insulated cable covered with lead, coated over with yarn or hemp, and then served with two coatings of steel ribbon, and the whole yarned over. Those armoured cables are simply buried in the ground, with a tarred board over them, to indicate where they lie should digging operations be going on near them.

I would just like to say one word on potential leads. They give more bother to keep in order than all the other mains put together. You will remember a slight explosion which occurred in Bath-street in November. The gas in the manhole was undoubtedly fired by a potential lead, which had never shown any signs of its insulation breaking down before. The gas in the manhole had not been accumulating there for weeks, but had gathered in a few days. A very badly damaged gas-pipe was found quite close to the manhole. We have had to renew our potential leads two and three times in several parts of the city, while in other parts they have given us no trouble. I have been told that in London stations a potential lead burning out is a common thing every five or six weeks. The potential leads or test wires we have tried consist of an insulated cable of copper wire containing seven strands of No. 20 gauge. Three such cables make up the lead going to one feeding point. These wires have been pulled into a 3in. cast-iron pipe in bunches of 12, and some have given no bother at all, while others have two and three times been found smouldering away in the pipe. The insulation of the cables is not damaged in the pulling in, as their insulation resistance has been taken from time to time and found to be quite good.

While speaking of insulation, I will just refer to the insulation we get on large insulated cables pulled into the street crossings. Although Silvertown and Henley cables have been used with a guaranteed insulation of 600 megohms to the mile—so that in a length of 20 or 25 yards the insulation one would expect is something like 45,000 megohms—instead of this, the insulation is more like 45,000 ohms, which, I think, is purely due to surface leakage along the covering of the cables to the pipe into which they are pulled. Again, we have here 600-megohm cables connected direct on to bare strip in which the insulation is not more than 300,000 ohms per mile. I consider that a high insulation is not of so great importance on underground mains, so long as you have a steady insulation resistance to earth of, say, 500 or 600 ohms. The leakage through this will amount to very little in the year compared to what is lost through shunt circuits in meters, voltmeters, etc.

I should think that some cheaper material not having such a high insulation resistance as rubber, but at the same time durable, must be used. Paper insulation has been used, but I do not know with what success. Here troughing might be employed, made strong enough to stand the weight of the traffic, but it would necessitate the manholes being very deep and large. Copper strip or rod might have circular porcelain insulators fixed on to them, and pulled into an iron pipe in place of the insulated cable.

A great deal has been said against and in favour of this bare copper strip and culverts. The bare strip and iron culverts have now been in Glasgow for fully a year and a half, and the current has been on the mains continuously for a year, and we have never had any more serious trouble with them than we have had with insulated cables in pipes. I think the copper strip is all right, but I do not care so much for the iron culverts. I would like to see the copper strip with a slight covering of some insulating material. There is no necessity for having finely-tinned copper flexible cables made to be below streets. Flexibility is not so very necessary in underground mains. We have not yet had long enough experience with the iron culverts to know the effect of years on them. Scale will probably form and drop off them and make short-circuits, but I am afraid the culverts will get very dirty in course of time and require cleaning out. I would like to see concrete or earthenware culverts made on the same principle as the iron ones.

Mr. Crompton says, in a letter of the 8th November: "It is very easy to prove that the 30 miles of mains laid in London consisting of bare strip are in as good order as when first laid, and that during the time they have been down—in some cases over seven years—they have cost less for testing, inspection, and maintenance than any other system that has been tried."

We have been troubled very little by gas in our manholes, and whenever we have smelled any, the Gas Department has immediately remedied it.

When anyone wishes a supply of electricity for lighting or motive purposes, he must fill up a form stating the amount of energy wanted. A branch of a suitable size of cable is then taken off the network—*never* off a feeder. If the branch is to be taken off at a part where the network consists of insulated cables in cast-iron pipes, a part of the pipe, about 18in., is cut out altogether. The two proper cables (either the positive and middle or middle and negative) are then bared, and the branch wires soldered on. The bare part is then covered over with rubber, and made as good as the original cable. A joint-box which has two small holes in its side is then bolted over the pipe and jointed with putty. Malleable iron pipes are laid from this joint-box into the consumer's premises, and the branch cables pulled into those.

The Corporation terminate their mains just inside the building line, in a main fuse-box supplied by them. A contractor does all the work inside the premises, and brings the mains to this fuse-box, leaving a bight at some suitable place for a meter, which the Corporation supply. If the connection is to be taken off the bare copper strip, the operation is simpler and easier. The pavement in front of the premises is lifted for about 5ft., and one cover (4ft. 6in.) is taken off the iron culvert. The copper strips are then tinned or filed clean, and the branch cable, which has previously had a skew thimble soldered to it, is clamped tight to the copper strip with a split grip-box. A short cover (3ft. 6in.) is then placed over one end of the culvert, where the branch has not been taken off, and a special cover, 1ft. long, having two holes in the side, is placed over the branch. Malleable-iron pipes are led from this cover into the consumer's premises as before, and the branch

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cables pulled into them. This method of taking off a branch is much simpler. It can be done in a third of the time an insulated joint takes, and is easier undone if it is found necessary to do so.

As I mentioned before, the current for the public arc lighting of the street is not supplied from the private supply mains, but is supplied from a station situated in John-street. The lamps are lit by means of a continuous high-pressure current. The mains for carrying this current consist of insulated cable of seven strands of No. 16 wire, and is carried in a cast-iron pipe laid alongside the troughing. A current of about 10 amperes at 3,000 volts is sent out from the station, and flows through 50 arc lamps connected in series. In the base of each lamp a switch is placed, by which the current may be turned completely off the lamp and allowed to pass on to the other lamps. This allows the lamp-trimmer to trim the lamp without any chance of receiving a shock, even although the current is on the mains.

For fully six months the Corporation have themselves continued the laying down of more mains, and I am quite sure that those mains have been put down better and more cheaply than they were done by the contractor. It was most unsatisfactory for the contractor to be hindered by gas branches in his way. The Corporation men can easily change the gas branch and continue laying the troughing without delay. In no manhole have we been bothered with gas where the gasmen have laid the troughing, for the simple reason that they have overhauled, and in a great many cases relaid, the gas-pipes all along the course of the electric light mains and round about the manholes.

I may state, in conclusion, that I am strongly in favour of corporations undertaking this sort of work themselves, more especially if the gas and electric light departments work as harmoniously together as they have done in Glasgow.

It would not be right that a paper on the underground electric light mains in Glasgow should close without referring to an article which appeared in one of the electrical contemporaries a fortnight ago. It begins by stating the date on which the recent explosions took place. It is interesting to note that an equal number of explosions took place while the mains were being laid and, of course, before any current was on the mains. The gas which had accumulated in the Bath-street explosion was fired by a short-circuit on a potential lead, as I said before; the one in West George-street by a naked light used by one of the workmen.

The third has not been explained, but a passer by states that he saw a flame playing about the manhole cover before the manhole cover blew up. This would seem to show that the gas which caused the explosion was fired from the outside, not from the *cables* in the manhole; no short-circuit or potential lead caused it.

How the gas got into the manhole was not, the writer of the article thinks, by infiltration; but he goes on to say that the culverts subside, and the weight of the troughs breaks the gas service main, allowing gas to blow in through the joint opened up by the subsidence. This is a very poor explanation, I think. Why should the ground begin to subside now? As a matter of fact, the ground below the troughs has hardly been disturbed at all. Again, most of the gas branches cross over the top of the troughing; the branches are of malleable iron, and are set in a V-shaped piece of wood, with fully an inch of pitch laid on the top of pipe. Again, had the troughs subsided, the copper strip would undoubtedly have touched the lid of the troughs and have made a short-circuit. This, however, has never happened.

The writer of the article says, with great confidence, "that buckling of the strip within the Glasgow culverts has taken place is certain," but where he got this information I cannot tell. In the same paragraph he says, "expansion joints are *now* being introduced at the junction-boxes, and this certainly is an important step." Those expansion joints were put on in March and April of last year, and I do not think an extra one has been put on since. Continuing, in the same paragraph, he says, "another great defect in the Glasgow culverts is that the several 4ft. 6in. lengths are not properly connected together electrically." Now, they are; there are 2⅝in. iron bolts holding the troughs together, and those are screwed up so tightly that I have seen a length of 20 yards of five-way undermined and no signs of the troughs subsiding.

The article concludes by referring to the foolishness of the Glasgow authorities pulling potential leads through cast-iron pipes, which are rough inside. He is again quite wrong here, as the pipes in which the potential leads have given way have been examined, and a hard ball pulled through to see that no rug or roughness was in the pipe, and none was found. If this was the cause of the wires giving way, the wires which had been pulled furthest would be the most damaged; but this is not the case.

On the whole, the article is untrue; and I think the electrical journal in question ought not to make such damaging statements about the mains in "the second city of the empire—the city of engineers" without first enquiring into the truth of them.

With regard to the ventilation of the manholes and troughs, there is now nearly 500 of those manholes in the city, and only some half-dozen have any trace of gas in them, and this is undoubtedly traced to gas-pipes damaged either by the operations of the underground railway or of the new sewer now being built in the city.

At the same time, we are continually on the look out for more gas escapes and reporting them to the Gas Department, who pay prompt attention to them. By this means we hope to prevent any further serious explosions.

THE THEORY AND DESIGN OF THE CLOSED-COIL CONSTANT-CURRENT DYNAMO.*

BY HENRY S. CARHART.

(Continued from page 141.)

Suppression of Sparking.

If we assume that the armature is well balanced electrically and magnetically, and that the brushes have a proper bearing in contact with a smooth commutator, the conditions required to commute the current without sparking are known to be as follows: With a two-pole dynamo, the current is divided through the armature—one half going from brush to brush through one side, and the other half through the other side. Hence when an armature coil is carried past the brush it is transferred from the one circuit through the armature to the other, and at the same time the current through it reverses its direction. This constitutes the act of commutation. But the sudden decay of a current through a coil in one direction and its growth to an equal value in the other gives rise to an E.M.F. of self-induction opposing the change. This E.M.F. will prolong the flow of the current on one side of the brush and will oppose its rise on the other side. Hence if the coil is short-circuited by the brush lapping over the two consecutive commutator segments to which its ends are connected, even when the coil passes the neutral plane of the dynamo, the E.M.F. of self-induction produces a local current through this coil; and when the one end of the coil slips past the brush and becomes a part of the other half of the divided circuit the current which should reverse through it meets the opposing current and breaks over the gap to the brush with a spark. Hence the commutation must not take place at the neutral plane, but in advance of it, and in a field where the induced E.M.F. in the coil shall be just sufficient to offset the self-induction, and in addition reverse the current in the coil while it is passing the brush or pair of brushes, and cause it to grow to the normal value at the instant when one end of it passes out from under the brush. The induction from the field must be sufficient to bring the one current to zero, and to set an opposite one of equal value flowing in the coil during the time it is under the brush. Then the commutation will be sparkless.

Now, if the current is kept constant in strength the field induction required to accomplish the results described is approximately the same whether the coil is short-circuited at one angle or another in advance of the neutral plane. It

* Paper read before the Franklin Institute, December 26, 1893.

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would appear at first thought that unless the induction in every part of the field from the neutral plane to a point nearly 90deg. in advance of it is substantially uniform, terrific sparking must result when the brushes are shifted far forward to vary the electric pressure to suit the requirements of the circuit, for if the induction is in excess of the requirements to accomplish the result described in the commuted coil, then a current will circulate through it during the short-circuit, and the rupture of this on leaving the brush will cause sparking. I have illustrated this action in the following manner. Separately excite the field magnets of a machine which can run on short-circuit even with a forward displacement of the brushes without sparking. Then, leaving the armature on open circuit, rock the brushes forward; the sparking will increase with each advance till it becomes terrific and endangers the machine. The induction to which each coil is subjected in an excited field produces a large current in it while it is under the brush, since there is less self-induction in the coil to offset the induction from the field than there is when the machine is self-excited and working in the normal way. There is another reason to be described later.

Considerations of this kind have led some writers to say that sparkless commutation for any position of the brushes can be accomplished only when the induction in the field is made uniform. The Statter constant-current machine in England is made on this principle. Portions of the pole-pieces are laboriously cut away at such points as to make the density of the lines of force entering the armature over a given angle equal. Of course, a machine built in this way will permit of shifting the brushes through a considerable angle in order to vary the potential difference without introducing sparking.

But while a uniform field accomplishes the result, no such uniformity is required; the same result may be secured in other ways. The first method already described weakens the field when the brushes move forward by cutting out ampere-turns in the field magnet. This reduces induction to the proper amount at each point without changing the overlap of the brushes. It is made necessary by the very high saturation of the armature core in this machine. It has the advantage of greater economy with small loads, because field resistance is cut out, but it requires a more complex arrangement of parts on the machine than suffices for the mere movement of the brushes.

The second method diminishes the overlap of the brushes as they are rocked forward. In the first place, this has the effect of diminishing the time allowed for the reversal of the current, but it also diminishes the number of turns of wire in the coil or coils included between the two parts of each brush. The curtailed time interval increases the self-induction of each convolution of wire because it increases the rate of charge of the current in the coil undergoing commutation; but this increase is counterbalanced by the diminution in the number of turns of wire short-circuited by the brush. Hence, the total self-induction during commutation remains not far from constant. When the brushes shift forward into a denser field, however, the diminution in the overlap decreases the number of turns of wire included between the pair of brushes composing either the positive or the negative, and so cuts down the total field induction in these coils during commutation to the amount required to suppress sparking. The overlap of the brushes must therefore be inversely as the induction in a coil under the brush is to different parts of the field, for the presence of the pole of the armature at any point reduces the induction. This point is a complicated one, and needs further experimental study.

But in the third class of machines the overlap of the brush is constant, and the field is not weakened by cutting out coils on small load. Neither are the pole faces cut away to produce uniform induction. Attention is given to the thickness of the pole-pieces so as to avoid unnecessary crowding of the lines of force toward the central portions. It is also desirable to avoid thinning of the polar horns lest they become saturated. In the old Sperry machine, which I have investigated quite carefully, each pole-piece is cut quite in two. In fact, as is well known, the field has four cores. At the same time the horns or pole tips are rather blunt. But this machine shows the violent sparking when separately excited, with the brushes far forward and the circuit through the armature open. The induction around the armature is not uniform, but the sparking is small for any position of the brushes with the normal current. The brush bears on about three commutator segments. I refer to this machine as an illustration of the class and not as a model of excellence. It is no longer built.

In this machine the induction to which a coil is subjected near the brush is not the same in different parts of the field, but diminishes as the brushes are rocked forward, the current being kept constant. With the exploring coil before described, and the two extra brushes bearing on the insulated copper ring and the fibre collar with brass segment respectively, the external circuit connecting the two small brushes was carried through a d'Arsonval galvanometer in shunt. The two extra brushes were attached to the two main brush-holders, but were insulated therefrom. With one brush making contact with the small brass segment, two and then three commutator bars in advance of the upper main brush, the following deflections were obtained with the galvanometer from maximum to minimum.

Deflections, two segments.	Deflections, three segments.
26	63·5
24	56
22	49
20	41
18	34
16·5	32
13·5	—
12·5	28
10·5	—

The steps were not the same in the two series of observations. No trouble was found in obtaining a steady deflection of the galvanometer, the dynamo making about 1,200 revolutions per minute. The exploring coil was therefore subject to a diminishing induction near the brush as it moved forward with the brush toward the centre of the polar surface.

A similar series of experiments made on an old Gramme machine of 3,000 or 4,000 watts capacity, built at the University of Michigan in 1876-7, gave a different result. The measurements were made by simply connecting a third brush to the upper brush-holder and measuring the potential difference between it and the main brush in different parts of the field. The actual induction to which the armature wire is subjected in different parts of the field and at the same distance of two commutator bars from the main brush is thus measured.

The following table contains one series of observations:

No. of observation.	Current in amperes.	P.D. between main brushes.	P.D. between main and third brush.
1	9·5	191	4·9
2	9·5	170	5·4
3	9·5	145	5·5
4	9·5	127	6·2
5	9·5	111	6·5
6	9·5	77	7·7
7	9·5	62	7·8
8	9·5	54	7·7
9	9·5	47	7·4

In this case the induction increases throughout the larger extent of the movement of the brush. But in this machine the knee of the characteristic curve is reached at about 13 amperes, while in the other machine it is found at seven amperes. The armature reaction in this older machine when run at 10 amperes is relatively less than in the other one run with the same current. This is further evident from the fact that with the old Gramme run at 10 amperes an increase in the current, due to lessening the external resistance, is always accompanied by an increase in the potential difference between the main and the third brush, while with the 10-light Sperry machine and others with similarly saturated field an increase in the current when the brushes are fixed decreases the potential difference between the main and extra third brush. The reason is this: If the field is saturated, but not the armature, an increase in the current does not appreciably increase the field, but it does increase the armature reaction, and so cuts down the total potential difference between the main

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brushes as well as between one main and a third brush; while with an unsaturated field and a magnetically weaker armature, an increment of the main current produces a greater increment in the field than in the armature reaction. With the same old Gramme machine run at about 18 amperes, an increment in the current produced a decrease in the potential difference both between the main brushes and the main and third brush. The armature reaction then became relatively larger than the increase in the field magnetism. But this old machine exhibits perfectly the property of governing by rocking forward the brushes on a diminishing load, with no more sparking in one position of the brushes than in another.

Hence it is clear that for practically sparkless commutation it is not necessary that the induction near but under the brush shall be a constant. The effective means by which, with constant current, the brushes can be set in any plane around the commutator cylinder is the reactive effect of the armature. This fact is brought out quite clearly by plotting the integrated potential differences between the upper or positive brush and the third movable one as ordinates to a horizontal line. The data are the same as were employed to plot the first curve in Fig. 1. If Fig. 2 is examined, a decided flattening in the curve will be found at 180deg., the position of the negative brush. The same flattening may be seen at 0deg. All curves, plotted with data obtained at different loads, show the same diminution or stay of the inductive process near the poles of the armature. The armature at these points paralyses the field. As the poles of the armature move around they sweep away the lines of force of the field, and only enough remain to produce an E.M.F. competent to offset the E.M.F. of self-induction, and, in addition, cause the newly-directed current to grow to its normal value as the coil passes out from under the brush.

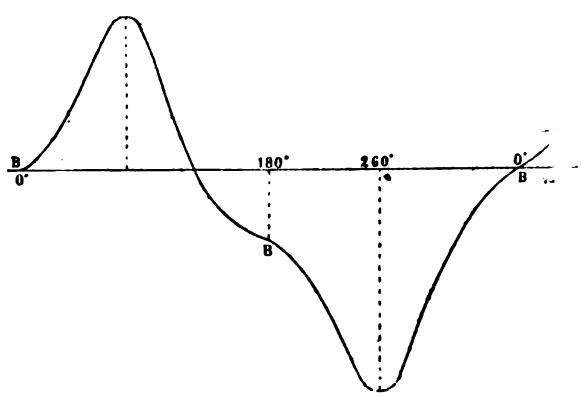

FIG. 2.

This reactive power of the armature may be utilised to effect approximately regulation for constant current without brush shifting. But for this purpose the load cannot be a maximum. The poles of the armature must be far enough forward to produce increase of magnetic leakage. As an example of what I mean, a 40-light machine had its brushes locked in such a position that it maintained 30 lights with 10 amperes current. Ten lights were then cut off, and then 10 more, with but small increase of sparking, and the ammeter showed an increase of current from 10 to 12 amperes only. A change of two amperes is within limits possible for practical lighting. The machine was then completely short-circuited by placing a large bar of iron across its terminals without dangerous sparking. This means that the characteristic of the machine beyond the crown of the curve approached a vertical line, the ideal characteristic of an automatic constant-current dynamo.

The conditions requisite for sparkless commutation of a constant-current machane are therefore quite clearly defined. The self-induction of the short-circuited coils must nearly balance the field in all positions of the brushes. Both Mr. Esson, in a paper before the British Institution of Electrical Engineers, and Prof. Ryan, in a paper before the American Institute of Electrical Engineers, lay down the condition that the brushes must be kept under the pole faces in order not to enter the weakened field between the pole corners. And yet I have seen constant-current machines working with the brushes beyond the extreme tips of the poles with no increase of sparking.

I do not regard this condition as absolutely essential, since at maximum E.M.F. the brushes may be moved through a considerable angle without appreciable change in sparking.

Prof. Ryan states in his paper above referred to, that "the magnetising force impressed by the field ampere-turns must be uniform at all points between the pole faces." This condition is favourable to sparkless commutation, but not essential. It has to do with the area of the sparkless position of the brushes for any given load. If the field is fairly uniform, this area will be about the same in different parts of the polar faces; if the field is far from uniform, sparkless commutation may yet be secured, but a smaller variation in the current will produce sparking than when the field is uniform, for the sparkless area on either side of the brush with a given external resistance is then much reduced. The region controlled by the armature poles is more limited in extent than when the field is uniform.

It follows that the single-magnet type of field is not suitable for a constant-current machine. This fact was remarked upon by Mr. Esson. For a two-pole machine the double-magnet type is to be preferred. If, then, the iron is reduced at the back opposite the middle of the polar surfaces, and the poles are thickened and rounded off rather blunt at the ends to prevent saturation, the field induction will be sufficiently uniform without the necessity of resorting to the chopping-away process applied to an English single-magnet machine described in Slingo and Brooker's "Electrical Engineering."

(To be concluded.)

NOTES ON A TRIP TO THE UNITED STATES AND TO CHICAGO, 1893.*

BY W. H. PREECE, C.B., F.R.S., PAST-PRESIDENT.

V. ELECTRIC LIGHTING.

(Concluded from page 147.)

The accumulator in America has been a failure for electric lighting, and a very strong prejudice exists against its use. It has led to much litigation, and the best forms seem little known there. The lagoons of the World's Fair grounds were, however, very successfully navigated by extremely pretty electric launches, worked and lighted by accumulators. The grounds at night, brilliantly illuminated and interlaced by winding waterways, with wooded islands and pretty bridges, along which illuminated gondolas and silent launches floated noiselessly, formed most beautiful and fairy-like scenes, superior to anything seen in Venice or pictured by art. The feature that distinguishes American from English practice is the persistent use of belting and countershafting. In some stations the belting was to English eyes appalling. Direct driving is only now making its way. There were several direct-driven engines and dynamos exhibited in the American section at the World's Fair, and some new stations now being built are to be direct-driven. The Willans and Robinson engines on show at the exhibition, and a steam-turbine exhibited in the Swedish section by Laval—a form somewhat similar to that of the Hon. Charles Parsons, who unfortunately did not exhibit—attracted much attention. The reports of our performances in England are much sought after, and I think one influence of the Chicago gathering will be to convert American engineers to direct driving. The elastic character of direct-driving engines, gradually increasing in number and capacity with the load, and the ability to shut down or turn on engine after engine as the load varies, are economical advantages of immense value. The rapid regulation of small engines, the much smaller space occupied where space is so valuable, the smaller capital expenditure involved, and the reduced working expenses, all give direct driving an advantage which should recommend itself to such eminently practical engineers as the Americans. The General Electric Company showed in the World's Fair a 1,000-h.p. triple-expansion vertical marine type engine, driving two 400-kilowatt multipolar dynamos, and the Chicago Edison Electric Light Company are fitting-up their new central station with direct-driving engines. The town work at such places as New York, Boston, and Chicago is as solid and substantial as anything we can show in England; but when we inspect the outlying works in country towns, we can only express our thanks that we

* Paper read before the Institution of Electrical Engineers.

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have the control of the Board of Trade and the protection of an Act of Parliament. It is the fashion to decry grandmotherly government, and to wince at departmental espionage; but the protection of life on our railways, the absence of accident in our electric light undertakings, and the character of the work done everywhere, as compared with the same conditions in the States, can lead to but one conclusion—viz., that if we are slower, we do these things at least better in England. It is all very well in the pioneer stage of any industry to let private enterprise have its full swing, but when an industry becomes a public necessity, and when the interests of the whole community are at stake, Government, as the custodians of the public weal, must step in and assume the control. The accidents in the States are terrible in their number and fatality, and they strike the observant Englishman with dismay. The value of life there seems to be very much below par.

VI. Electric Railways.

The progress made in the establishment of electric railways is the most wonderful instance of growth of electric industry observable in the States. In 1884 I found only one railway so worked, and that experimentally, at Cleveland. Now every town has its electric railway. There are 4,000 miles of line so worked, 6,900 motor cars, and 4,000 trailing cars.* The capital embarked is 13,000,000dol., and the rate of progress is scarcely checked by the serious financial depression that has passed over the country. Electrical appliances of all kinds for railway working were among the most conspicuous exhibits at the World's Fair. A special track was laid down for test and trial, and along here I inspected a 30-ton locomotive, the heaviest yet made, having a horizontal pull on the level of 6,000lb., or enough to draw 500 tons on an ordinary English railway. The type of railway in general use over the United States of America is very uniform. We have only one true example in England, and that is at Leeds. A modification of the system has, however, been adopted on the South Staffordshire tramways, and is about to be introduced in Coventry. The wires are all overhead. A heavy insulated copper wire is suspended over the centre of each pair of rails or "track," and called the "trolley" wire. This conveys the current from the power-house. It is picked up by a trolley rod, which presses, by the action of a spring, upon this wire, and so conveys the current to the motors, which are geared to each of the two wheel shafts of the car. The current is thence transmitted through the wheels to the rails, and it returns thence to the power-house by heavy copper returns buried in the ground or suspended on the poles. There are two very fine specimens of electric railways in Chicago. One, the Intramural Railway, conveying visitors to and from different parts of the grounds of the World's Fair, working very well, carrying an immense number of people, and financially very successful. It is not a trolley line, but it has a third rail acting as the main conductor. The other is the Chicago North Shore Street Railway, running to Evanstown. This is a trolley line, having iron poles of strong design and good taste. It is 7½ miles long, with a power-house situated in the middle of the line. It has 16 motor cars and 16 trailers. The feeders are carried on wooden poles, which are very unsightly. These feeders could have been more economically and more efficiently put underground. In the power-house they are using a simple horizontal reciprocating engine, driving a Thomson four-pole dynamo, fitted with carbon brushes, by means of continuous rope gearing. No sparking whatever is observed at the brushes, and nothing can work more smoothly; but the absence of condensing and the existence of rope gearing must render the engine part uneconomical. The maximum horse-power used is 246. The voltage varies with the load from 500 to 550. The current averages 200 amperes. The maximum number of cars on at one time is nine motors and nine trailers, and this averages at the power-station 13·7 h.p. per car running. The cars run on the straight at from 16 to 20 miles an hour. The rails are 85lb. per yard—a very heavy rail for a tramway. The usual rail is 52lb. per yard, as at Boston; but experience in the United States of America is leading to heavy rails. The pounding and hammering on the rails with heavy loads is very great, and in Philadelphia they are using even 90lb. rails. The trolley wire alone is not unsightly, but when it is protected with three guard wires, as at Boston, and the same poles carry the feeders, it becomes hideous, and it is astonishing that the American community submit to it. Such a system is impossible in England. This trolley wire must be elastic, otherwise the trolley itself frequently jumps off and stops the car. Attempts have been made to improve the appearance of the road by using handsome central iron poles, with solid brackets on each side to carry the two trolley wires, but the want of elasticity has introduced fresh evils. The trolley frequently comes off, and great sparking is evident. An admirable illustration of a modern electric railway is the electric *portage* between Lakes Ontario and Erie, from Chippewa to Queenstown, 13 miles long. It is on Canadian soil, and built with Canadian capital, but the work was done by an American firm. It is an open overhead trolley line, with iron posts and brackets. It is worked by water power derived from the Niagara Falls. The West End railway system of Boston is by far the most extensive electric railway system in any city in the States. In the power-station, which is situated on the harbour, there are 24 Babcock-Wilcox water-tube boilers, each developing 250 h.p. Surface condensing is used, sea-water being available for the purpose. There are six horizontal triple-expansion engines, each developing 1,000 h.p., and driving by means of belting 18 Thomson-Houston four-pole dynamos, all capable of being connected up in parallel, but put on and off as the load varies. The chimney is 252ft. high and 13ft. 6in. in diameter. It does not smoke, and the steam is generated so economically that only 11½lb. are used for one horse-power hour. There are three power-houses in Boston, the other two developing 2,000 h.p. each, so that there are 10,000 h.p. used in Boston for working their street railway system. The line is no longer run by contractors. It is entirely in the hands of the railway company itself. They have magnificent workshops, and a very fine staff. The chief engineer, Mr. Hirt, was extremely attentive and communicative. He supplied me with capital drawings of the works and general arrangements. The use of belting was again surprising; but I was told that a very large railway system at Brooklyn was going to be worked by direct-driven power, so as to obtain an authoritative and convincing trial of the relative merits of the two systems. I did not learn the type of engine to be fixed at Brooklyn, and I was unable to go there to find out. The track is light, as I have previously mentioned, but they are welding together the fishplates and the rails so as to obtain an electrically perfect return circuit. I saw the car and apparatus used for this welding process, but I could not see it in operation, for one essential part of the plant was being repaired. I saw the electric snow-ploughs used to keep the tracks clear in wintry weather. The system of railway working in Boston has given such satisfaction to the public that the traffic returns have improved 30 per cent. owing to the change from horses to electricity. The service is so much quicker, cleaner, and better performed. A railway car in full service is said to run an average distance of 250 miles a day, and its mean speed is 15 miles an hour. There is an important question under discussion in the United States of America—whether it is better to pursue the present practice of using two motors, one on each wheel axle, or to use only one motor connected electrically and flexibly with the wheels by bevelled gearing. This is the plan advocated and practically carried out by Mr. Sperry. The weight is thus placed in the middle. The horizontal pull is said to be greater. The starting torque is smaller. It is more easily controlled. There is no slip, and the velocity of all parts is uniform. It will climb a stiffer grade. One 35-h.p. motor replaces two 30-h.p. single-reduction Thomson-Houston or Westinghouse motors with economy of energy. The system is working in Pittsburg, where it was adopted after a very severe trial with a Westinghouse car, and it is about to be used on Twenty-second-street in Chicago. It has this disadvantage—that if the motor fails there is not a second one available to take the car home. The problem is an interesting one, and its solution will be watched with great interest, for it has an important bearing on the economies of our English roads. The feeling is pretty prevalent in the States that the conductors must eventually go underground. Experiments in this direction are being made in several directions, notably in Washington and Chicago. The trolley with its guard wires is really an abomination, and the disturbances created by insufficient return accommodation are annoying the telegraph and telephone interests, and alarming the gas and water companies. The future working must be metallic circuits and underground conduits. It is so done in Budapest, and it has been partially done in Blackpool and in Rome. Other experiments are contemplated in England. No one can doubt that the future of electric railways is very bright. The South London Railway and the Mersey Dock Elevated Railways are examples of great successes in England, but it is in the States, where this form of locomotion has become a necessity, that we are sure to see a speedy and practical solution of the problem.

* Trailing cars are not fitted with motors. They carry passengers only, and are drawn by motor cars.

Conclusion.

I have by no means exhausted the notes made during my trip, but I have said enough. Interviewing is a feature of American journalism that, thank goodness, has not taken root here. I was surprised to read of interviews with myself, extending to two or three columns, that resulted from the passage of a few compliments; but I was more surprised to find that statements supposed to have been made by me to an interviewer were taken *en serieux*. One irate functionary compared an official statement of our Postmaster-General with a mythical statement made by me, and triumphantly pointed out such a glaring contradiction as a complete refutation of my fallacies. I even read that I had stated that we electricians in England had nothing to learn from America. I have no recollection of ever having made any remark which could by any shorthand blundering have

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been construed into such an absurdity; but if I had done so it would more likely have been one where "nothing" was a telegraphic error for "everything." I cannot too gratefully speak of the attention and kindness I received from everyone, and I certainly feel that I have personally profited from my visit very much indeed. A visit to the United States is something like charging an accumulator. It stores the visitor with energy. When I am discharged, and my adverse criticisms have been forgotten, I shall probably cross the Atlantic again.

PHYSICAL SOCIETY, January 26, 1894.

Prof. A. W. RUCKER, M.A., F.R.S., president, in the chair.

Mr. J. W. Kearton read a "**Note on a New Mode of Making Magic Mirrors.**" The author's first idea was that the magic properties were due to differences in reflecting power, but experiments showed this to be improbable, and indicated that the patterns visible by reflected light were due to slight concavities in the surface. Several methods of producing such changes of curvature were tried, such as electro-depositing and electrical etching, the plate being subsequently polished to remove sharp edges. The method found most satisfactory was to draw the figures on polished brass covered with wax, and etch them by immersing in nitric acid, subsequently scouring with charcoal, Sheffield lime, and swandown calico until all direct traces of the figures disappeared. The scouring rounds off the edges and makes the depressions concave, the two eventually forming one concave sweep, which makes itself visible when light is reflected from it on a screen. To obtain satisfactory results with figures having broad and narrow lines it was found necessary to paint over with hot wax the fine lines and the outer edges of the broad ones after the first immersion; a second immersion etched the middle parts of the broad lines deeper. By repeating the process, the broad lines were etched roughly concave in steps, and the scouring made the curvature continuous. Figures in relief, showing the patterns in shade on reflection, were obtained by painting the pattern on the plate in sealing-wax dissolved in naphtha, and etching away the uncovered portions by an immersion of one two seconds. A number of mirrors with patterns in intaglio and relief were exhibited to the meeting. **Prof. S. P. Thompson** said the chief interest of Mr. Kearton's work was that he had succeeded in producing mirrors by a process which Prof. Ayrton had found unsuccessful. The special polisher used by Mr. Kearton might have something to do with the result obtained. Some of the mirrors had been gilt after polishing and the reflected pattern improved thereby. **Prof. Ayrton** said he was greatly interested to see that mirrors could be produced by the chemical method. The polisher used by the Japanese was the flat end of a tight bundle of special straw cut crosswise. When the true explanation of the magic properties was found out, the chemical method was not pursued further. The **Rev. F. J. Smith** mentioned that he had produced magic properties on silvered glass by the inductoscript method. Although no markings could be seen directly, the pattern showed itself when light was reflected from the surface to a screen.

Mr. W. B. Croft, M.A., read a paper on "**Some Observations in Diffraction,**" and exhibited a large number of photographs of diffraction figures obtained under different conditions. The first series exhibited related to diffraction from parallel light (diffraction of Fraunhofer and Schwerd), and were obtained by placing various combinations of thin circular lines of light on a dark glass plate before the object-glass of a telescope focussed on a star. Spectral images of the star are formed by interference from the edges of the lines, thus giving diffraction patterns whose form depends on the shape of the aperture employed. The next series illustrated diffraction in shadow (Fresnel's diffraction), and were produced by condensing light on a minute pinhole, and placing the object between the hole and a microscope eye-piece. Beyond the eye-piece the camera used for photographing the phenomena was placed. Permanent records of remarkably good diffraction figures were obtained in this way, both of the combination of circles above mentioned and of various other objects and geometrical forms. After showing geometrically that diffraction bands from narrow obstacles and openings were wider than those from broader ones, the author explained the conditions necessary for making the bands visible, and pointed out the distinction between internal and external bands. Prominent amongst the photographs were several showing "Arago's white spot" at the middle of a shadow, and, in particular, this well-known phenomenon was shown as produced by so large an object as a threepenny-piece. Speaking of diffraction in a microscope, the author said little doubt need exist as to whether an image represented the real object or a diffraction modification thereof, for the latter were usually of a more misty and complicated character. Departing somewhat from the subject of diffraction, an excellent photograph of conically refracted pencils was shown, consisting of circular lines of light produced by passing light from pinholes through a crystal of arragonite. **Dr. Johnstone Stoney** thought the obtaining of permanent records of diffraction phenomena of great importance, and was particularly interested in the photograph showing conical refraction. **Prof. S. P. Thompson** said he had never seen diffraction effects exhibited to an audience so well before. He noticed that in several of the photographs Arago's spot was unintentionally shown to perfection in the shadows of dust particles. The **President** greatly appreciated the fact that the conical refraction photograph had been exhibited for the first time before the Physical Society.

A "**Note on a New Photometric Method and a Photometer for Same**" was read by **Mr. J. B. Spurge**. The method consists in using two diffusing screens (illuminated respectively by the lights to be compared) as secondary sources, and adjusting to equality the luminosity of equidistant internal surfaces by varying the apertures through which the light passes from the screens to those surfaces. By reducing the sizes of the apertures, the author has been enabled to compare lights of different colour; for when of sufficiently feeble intensity, coloured lights are indistinguishable from white or grey. The photometer is made up of two tubes, mounted at 45deg. to an axis, about which one of them is capable of rotating. When in the same horizontal plane the axes of the tubes form the sides of an isosceles right-angled triangle, at the middle of whose hypothenuse the light to be tested is placed; this illuminates one of the screens, whilst the standard light shines on the other. These screens used as secondary sources are situated a short distance away from the outer ends of the tube, whilst the inner surfaces of the near ends of the tubes are varied by means of a mirror. By turning the movable tube about the inclined axis and rotating the source about a vertical axis, the illuminating effect of the source in any direction can be tested. **Captain Abney** said the law of inverse squares was not true for weak lights, for the proportions in which the light from sources of equal intensity had to be reduced to appear white or grey depended greatly on the colour, being much greater for violet than for red. Only for the yellow-green rays was the ordinary law of illumination true when the intensities were feeble. **Mr. Blakesley, Prof. S. P. Thompson,** and the **President** also took part in the discussion.

LEGAL INTELLIGENCE.

GOLD TRUST COMPANY v. THE ELECTRIC TRAMCAR, LIMITED.

This motion was heard last week in the Chancery Division of the High Court of Justice, before Mr. Justice North. It was a motion in a debenture-holder's action to commit Alfred James Jarman, of 71, St. John's-hill, Clapham Junction, and Watson Smith, of 63 and 64, New Broad-street, to prison for contempt of Court in interfering with the receiver of the Court by having taken away from a certain shed accumulators and other property of the defendant company. It appeared that Jarman was a person who had been employed by the receiver and had a key of the shed. Watson Smith was manager of a company called the Elieson Accumulator Syndicate. He had contracted to buy from the receiver certain tramcars, accumulators, and plant for £250, and patent rights for £10, to be paid on delivery. He purported to sell the same chattels to the Elieson Accumulator Syndicate for £2,000, partly to be paid for in debentures. That company immediately contracted to sell the same property to a trustee for a new company for £15,000. The accumulators and some other goods were removed by Watson Smith with the aid of Jarman, without paying anything or leave from the receiver.

Mr. George F. Hart appeared for the plaintiffs in support of the motion.

Mr. J. W. Clark, for Jarman, pleaded that the conduct of his client was *bonâ fide*, though mistaken.

Mr. Watson Smith appeared in person.

Mr. Justice North made an order for the committal of both Jarman and Watson Smith. In the course of his judgment he observed on the difference of amount between the prices named in the three contracts. He could not say whether the price in one case was too high, or in another too low. That he had nothing to do with. Commenting on the evidence, he said he could not see anything *bonâ fide* in the conduct of the respondents; on the contrary, he might give it a very different name. As an order for committal was pressed for, he must make it.

COMPANIES' REPORTS.

INDIA RUBBER, GUTTA PERCHA, AND TELEGRAPH WORKS COMPANY, LIMITED.

Directors: S. Wm. Silver, Esq., chairman; Abraham Scott, Esq.; Matthew Gray, Esq., managing director; Robert Henderson, Esq.; the Hon. Henry Marsham; A. Weston Jarvis, Esq.

Report of the directors for the year ending December 31, 1893, to be presented at the thirtieth ordinary general meeting of the shareholders, to be held at the Cannon-street Hotel, E.C., on Thursday, February 15, 1894, at 12 o'clock noon.

The annexed accounts show the net profit for the past year to be £94,607. 4s. 2d. Adding £46,844. 17s. 5d. brought forward, and deducting £25,000 interim dividend paid in July, there remains a disposable balance of £116,452. 1s. 7d. The directors have added £50,000 of this balance to the reserve fund, and recommend the distribution of a dividend of 10s. and a bonus of 5s. a share, free of income tax, amounting to £37,500, making, with the interim dividend, a total payment for the year of 12½ per cent., and leaving £28,952. 1s. 7d. to be carried forward. The Company's general business continues to increase. The cable for the Central and South American Telegraph Company mentioned in the last report was duly laid, and a few other cable manufacturing and repairing contracts were carried out during the year. The efficiency of the Silvertown and Persan factories is maintained. Mr. Scott and Mr. Henderson, the directors retiring by rotation, offer themselves for re-election.

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CAPITAL.

The authorised share capital of the Company is £812,000.

BALANCE-SHEET, DECEMBER 31, 1893.

Dr. *Capital and Liabilities.*	£	s.	d.
Share capital—amount paid on issue of 50,000 shares of £10 each	500,000	0	0
Mortgage debentures	200,000	0	0
Reserve fund	450,000	0	0
Steamers' maintenance fund	10,000	0	0
Debts owing by the Company	35,824	10	6
Unclaimed dividends	17	0	0
Proposed dividend of 5 per cent. and bonus of 2½ per cent.	37,500	0	0
Amount carried forward to 1894, as below	28,952	1	7
	£1,262,293	12	1

Cr. *Assets and Expenditure.*	£	s.	d.
Freehold and leasehold premises (Silvertown, Persan, London, and Liverpool), machinery, and steamships	488,543	2	5
Debts owing to the Company	122,381	16	5
Cash with bankers, on deposit, and in hand	66,299	18	7
Bills receivable	3,293	9	10
Stock-in-trade, including cable and expenditure on account of contracts	229,200	1	6
Debentures and shares in other companies	207,042	3	5
Cash, stock, etc., at Persan and agencies	145,532	19	11
	£1,262,293	12	1

PROFIT AND LOSS ACCOUNT, YEAR ENDING DEC. 31, 1893.

Dr.	£	s.	d.
Salaries, interest, rent, rates and taxes, repairs, and general expenses	64,406	12	9
Bad debts	916	17	6
Income tax	2,084	15	0
Depreciation written off buildings and machinery	16,045	11	0
Directors' remuneration (minimum)	2,000	0	0
Balance—profit for the year, carried down	97,607	4	2
	£183,061	0	5

	£	s.	d.
Addition to reserve fund	50,000	0	0
Interim dividend of 5 per cent. paid in July £25,000 0 0			
Proposed dividend of 5 per cent. 25,000 0 0			
,, bonus of 2½ per cent. 12,500 0 0			
	62,500	0	0
Balance to be carried forward to 1894	28,952	1	7
	£141,452	1	7

Cr.	£	s.	d.
Gross profit, including interest on securities, and after charging commission	183,061	0	5
	£183,061	0	5

	£	s.	d.
Balance brought down	97,607	4	2
Less additional remuneration due to directors after payment of 10 per cent. to shareholders	3,000	0	0
	94,607	4	2
Amount brought forward from 1892	46,844	17	5
	£141,452	1	7

NEWCASTLE AND DISTRICT ELECTRIC LIGHTING COMPANY, LIMITED.

Directors: John D. Milburn, Esq., chairman; the Hon. C. A. Parsons, managing director; Sir B. C. Brown; Colonel W. M. Angus; John B. Simpson, Esq. Jas. Patterson, secretary. W. D. Hunter, engineer.

Report of the directors to be presented to the shareholders at the seventh ordinary general meeting of the Company to be held at 57, Westgate-road, Newcastle-on-Tyne, on Monday, February 12, 1894, at 2.30 p.m.

The directors have pleasure in again reporting that the supply of current continues to give satisfaction to the Company's consumers. The installations connected to the Company's mains during the year are equal to 4,000 10-c.p. lamps, bringing the total up to about 18,500, and 388,422 units of electrical energy have been supplied, as against 290,469 units supplied in 1892. During the past year 3,308 yards of main and branch piping have been laid, together with 6,579 yards of main and branch cable. After some difficulty in carrying through the drift to the river, the condensing plant referred to in last year's report is now in operation, and although it has been working only about three months, a considerable saving has been effected in the consumption of fuel and water. The gross earnings during the year amount to £2,949.12s.3d., and after paying interest and making provision for reserve fund and depreciation, and writing off £100 from formation expenses, your directors are able to recommend a dividend at the rate of 3 per cent. for the half-year ending December 31 (less income tax), which, together with the interim dividend paid in July last, makes the dividend 5½ per cent. for the year. Mr. John D. Milburn and the Hon. C. A. Parsons retire by rotation, but are eligible, and offer themselves for re-election as directors. The auditors, Messrs. Strachan and Co., also offer themselves for re-election.

Dr. BALANCE-SHEET, DEC. 31, 1893.			£	s.	d.
Capital—5,000 shares at £10 each			50,000	0	0
3,535 shares, £8 called up			28,280	0	0
1,031 shares, £6 called up			6,186	0	0
			34,466	0	0
Add calls paid in advance			612	0	0
			35,078	0	0
Less calls unpaid			240	0	0
			34,838	0	0
Debentures			9,200	0	0
Loans	£700	0 0			
Creditors	1,425	3 2			
Bankers	458	14 5			
			2,583	17	8
Reserve fund			650	0	0
Profit and loss account—					
Balance from last year	86	0 3			
Profit for year ending Dec. 31, 1893	1,517	7 6			
	1,603	7 9			
Less interim dividend	683	4 3			
			920	3	6
			£48,192	1	1

Cr.	£	s.	d.
Amount expended to date on buildings and plant, pipes and cables (including cost of laying), meters, transformers, electrical instruments, etc.	44,839	6	2
Less amount written off for depreciation	1,550	0	0
	43,289	6	2
Office furniture	149	19	2
Stock of stores, etc.	182	0	8
Cost of license, provisional order, etc.	581	16	10
Formation expenses £800 0 0			
Less amount written off 100 0 0			
	700	0	0
Debtors (less reserve for discounts)	3,233	12	7
Cash in hand	55	5	8
	£48,192	1	1

PROFIT AND LOSS ACCOUNT YEAR ENDING DEC. 31, 1893.

Dr.	£	s.	d.
Wages, salaries, rent, rates, taxes, and directors' fees	2,045	17	1
Stationery and office expenses	198	6	8
Stores, fuel, water, etc.	1,794	0	6
Repairs and renewals	233	12	5
Balance carried down	2,949	12	3
	£7,221	8	11

	£	s.	d.
Interest	532	4	9
Proportion of formation expenses written off	100	0	0
Tranferred to reserve fund	200	0	0
Depreciation written off	600	0	0
Balance carried to balance-sheet	1,517	7	6
	£2,949	12	3

Cr.	£	s.	d.
Electric energy supplied, less discount	6,880	17	7
Meter and transformer rent	339	16	4
Transfer fees	0	15	0
	£7,221	8	11

	£	s.	d.
Balance brought down	2,949	12	3
	£2,949	12	3

KENSINGTON AND KNIGHTSBRIDGE ELECTRIC LIGHTING COMPANY, LIMITED.

Directors: Alfred Sohier Bolton, Esq.; Sir Frederick J. Bramwell, Bart., F.R.S.; G. H. Hopkinson, Esq.; Granville R. Ryder, Esq.; R. W. Wallace, Esq.

Report of the directors to be presented at the seventh ordinary general meeting to be held at 1, Great George-street, Westminster, on Thursday, February 15, at 5 p.m.

The directors submit to the shareholders a statement of the accounts of the Company, together with a report of the position of the undertaking at the end of the year 1893. The district of the parish of St. Mary Abbotts, Kensington, arranged to be purchased from the Chelsea Electricity Supply Company, Limited, was transferred to this Company in June last, the necessary statutory powers having been obtained. As far as can be judged from the experience of one half-year, there is every reason to anticipate a satisfactory result from this addition to the Company's area. The mains, which extended to a length of 13 miles on December 31, 1892, have been increased during the year 1893

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to 16¼ miles—of which increase two miles are due to the new district and 1½ to the extensions of the Company's original system. During the year the number of houses and shops connected with the system has increased from 550 on December 31, 1892, to 734 on December 31, 1893; while the number of lamps calculated on the usual basis of 8 c.p. has increased from 47,441 to 64,529. Out of the total increase the new district represents 83 houses and shops, and 5,262 lamps Thus the increase on the Company's original district is 101 houses and shops, and 11,826 lamps. After paying the dividends on the 6 per cent. first preference shares to June 30, 1893, on the 5 per cent. second preference shares to September 30, 1893, and an interim dividend at the rate of 4 per cent. per annum on the ordinary shares for the first half of the year, the balance standing to the credit of the net revenue account for the year 1893 is £4,788. 7s. 9d. Of the above sum £1,456. 4s. 7d. has been appropriated for the payment of the first preference dividend to the end of the year, and £88 has to be set aside to meet the portion of the dividend on the second preference shares to the same date, leaving £3,244. 3s. 2d., out of which it is proposed to pay a further dividend on the ordinary shares, at the rate of 6 per cent. for the past half-year, making a total dividend for the year of 5 per cent. This will leave a balance of £1,059. 15s. 8d. No provision has been made in the accounts for directors' remuneration. In accordance with the articles of association, Mr. R. W. Wallace and Mr. A. S. Boulton retire from the directorship, and, being eligible, offer themselves for re-election. The auditors, Messrs. Lovelock, H. W. Whiffin, and Dickinson offer themselves for re-election.

Dr. BALANCE-SHEET, DECEMBER 31, 1893.	£	s.	d.
Capital, 15,000 ordinary shares of £5 each	75,000	0	0
,, 10,000 6 per cent. first preference shares of £5 each	50,000	0	0
,, 1,452 5 per cent. second preference shares of £5 each	7,260	0	0
,, mortgage debentures, 4½ per cent.	42,000	0	0
Sundry creditors and open accounts	5,579	13	11
Renewal account, balance at credit thereof	2,263	5	0
Net revenue account	4,788	7	9
	£186,891	6	8

Cr.	£	s.	d.
Plant, buildings, mains, furniture and fittings, provisional orders, goodwill, and South Kensington district, at cost	166,713	8	2
Freehold and leasehold property £9,213 3 11			
Less sinking fund 415 8 0	8,797	15	11
Preliminary expenses and cost of debenture issue 879 11 6			
Less amount written off 379 11 6	500	0	0
Sundry debtors	7,631	19	10
Stock-in-trade and stores	609	18	5
Consols	549	3	10
Cash at bankers—C. Hopkinson and Sons 362 12 10			
Cash at bankers—London and County Bank 314 5 1			
Cash in hand 12 2 7	689	0	6
Suspense account (law) 2,179 13 0			
Less amount debited to law charges 779 13 0	1,400	0	0
	£186,891	6	8

REVENUE ACCOUNT YEAR ENDING DECEMBER 31, 1893.

Dr.	£	s.	d.
Manufacturing electricity, coal, oil, water, waste, wages, and sundries	4,147	3	11
Repairs to leasehold property	17	14	0
,, apparatus on consumer's premises	12	16	8
Incandescent lamps	52	9	9
Salaries	1,489	15	6
Amount written off preliminary expenses	379	11	6
Miscellaneous expenses, including law charges	1,339	10	5
Company's auditor	31	10	0
Board of Trade auditor	38	0	0
Bad debts	71	5	1
Rent, rates, and taxes	821	19	8
Insurance	131	0	0
Renewal account in respect of buildings, mains, plant, batteries, and meters	4,059	3	6
Sinking fund, leasehold property	103	0	0
Balance	9,049	10	11
	£21,744	10	11

Cr.	£	s.	d.
Sale of electricity (units 724,308)	24,026	14	10
Less rebates	3,280	7	10
	20,746	7	0
Rent of meters	756	7	8
Sale and maintenance of lamps	49	16	3
Rent receivable	185	0	0
Transfer fees	7	0	0
	£21,744	10	11

Dr. NET REVENUE ACCOUNT.	£	s.	d.
Interest on temporary loans	22	17	0
,, ,, sinking fund	12	0	0
,, ,, debentures accrued to date, less income tax	1,712	16	7
Dividend on 6 per cent. first preference shares to June 30, 1893 £1,456 5 0			
Interim dividend at 4 per cent. per annum on ordinary shares to June 30, 1893 1,456 4 7			
Dividend on 5 per cent. second preference shares to September 30, 1893 134 4 1			
	3,046	13	8
Balance	4,788	7	9
	£9,582	15	0

Cr.	£	s.	d.	£	s.	d.
Balance from last account	3,792	13	5			
Less dividends to December 31, 1893, 6 per cent. first preference shares, £1,462. 10s.; ordinary shares, £1,462. 10s. 4d.; directors' fees, £350	3,275	0	4			
				517	13	1
Interest				15	11	0
Balance brought from revenue account				9,049	10	11
				£9,582	15	0

Dr. RENEWAL ACCOUNT.	£	s.	d.
Maintenance of buildings, mains, plant, meters, instruments, etc.	2,762	3	6
Plant written off	1,097	0	0
Balance	2,263	5	0
	£6,122	8	6

Cr.	£	s.	d.
Balance from last account	2,063	5	0
Amount brought from revenue account	4,059	3	6
	£6,122	8	6

BUSINESS NOTES.

Great Northern Telegraph Company.—For the month of January the receipts were £21,000.

Aberdeen.—The Town Council on Tuesday negatived a proposal to erect six arc lamps in Union-terrace.

Blackburn.—The Corporation seal has been fixed to contracts for electric lighting and other appliances.

Western and Brazilian Telegraph Company.—The receipts for the week ended February 2 were £3,207.

Liverpool Overhead Railway.—The traffic receipts of this railway for the week ending 4th inst. amounted to £632.

Westminster Electric Supply Corporation.—A dividend at the rate of 5 per cent. per annum for the half-year has been declared.

Direct Spanish Telegraph Company.—The receipts for the month of January were £8 more than for the corresponding period of 1893.

Cuba Submarine Telegraph Company.—For the month of January the receipts were £24 more than for the corresponding period of 1893.

Eastern Telegraph Company.—The receipts for the month of January were £64,851, as against £60,516 for the corresponding period of 1893.

West India and Panama Telegraph Company.—The receipts for the two weeks ended January 31 were £425 less than for the corresponding period of 1893.

Eastern Extension Telegraph Company.—For the month of January the receipts show a decrease of £3,363 as compared with the corresponding period of 1893.

Ruthin.—The town clerk has been directed to call a meeting of the Electric Lighting Committee, at which he would present the report he was directed to prepare.

Telegraph Construction and Maintenance Company.—The Board recommend a balance dividend of 15 per cent. making a total distribution of 20 per cent. for the year 1893.

Social Gathering.—The annual social gathering of the employés in the different departments of the Glasgow district of the National Telephone Company was held last week in the City Hall Saloon.

Coventry.—The Town Council have appointed Messrs. G. and I. Steane architects for the buildings of the electric light station, and they have been instructed to prepare plans and specifications with a view to obtaining tenders.

Milde Telephones and Electric Supply Company, Limited.—This Company has been registered with a capital of £20,000 in £1 shares to carry on the business of a telephone, telegraph, and electric light, heat, and power supply company.

English-Made Carbons.—The Atlas Carbon Manufacturing Company, Limited, of 17, Ewer-street, Southwark, S.E., draw our attention to the fact that they have for some years manufactured carbons for electric lighting, and also battery carbons.

Accepted Tender.—The tender of Messrs. S. J. Waring and Sons, at £228, has been accepted for supplying and fixing mahogany panelling and electric light fittings in offices, the Exchange, Liverpool, for Messrs. Clay, Medwood, and Co.

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Beverley.—The clerk to the Local Board has laid before the Board estimates from two firms for making telephonic communication between the new infirmary and the workhouse. Eventually the Local Board agreed to leave the matter to be considered by the House Committee.

Forthcoming Wedding.—The marriage is announced to take place of Miss Beatrice Agnes Mary, daughter of the Rev. Charles S. Morgan, of Cape Town, South Africa, to Mr. Henry D. Wilkinson, on Tuesday, the 20th inst., at Christ Church, Crouch End-hill, at two o'clock.

City and South London Railway.—The receipts of the Company for the week ending February 4 were £951, against £956 for the same period last year, or a decrease of £5. The total receipts for the first half-year of 1894 show a decrease of £120 compared with those for the corresponding period of 1893.

Oswestry.—The Town Council have referred to the General Purposes Committee an amendment proposed by Alderman R. Lloyd, that the following streets only be left in the compulsory part of the Act for electric lighting: Oswald-road, Cross-street, Leg-street, Church-street, and parts of Willow-street and Salop-road.

Ballymena.—At a meeting of the Town Commissioners on the 5th inst., Mr. Burns moved a resolution that they should advertise in the local and Belfast papers, and also in the *Electrical Engineer*, asking for tenders to light the town from August 16 till May 16 either by gas or electricity. Mr. Graham seconded the motion, which was passed unanimously.

Sunderland.—In connection with the provision of the electric light at Sunderland, eight tenders have been submitted to the Highways Committee for the erection of the necessary buildings for the storage of the requisite plant. The highest was £4,053, and the lowest £3,167. The latter was from Mr. T. P. Shafto, Sunderland, whose quotation was accepted.

Dover.—The Town Council have received a report from Mr. Slings, electrical engineer, who had been asked to report on the proposed Board of Trade by-laws on electric light. Several small alterations were recommended, but the report principally was a strong objection to the proposed sanction of overhead wires. It was decided to forward the report to the Board of Trade.

Tenders Wanted for Dewsbury.—Tenders are invited by the 15th inst. for lighting the workhouse and premises by electricity, for the Guardians. Plans and specifications may be seen, and forms of tender obtained, upon application to Mr. Joseph Peace, clerk, Union Offices, Wellington-street, Dewsbury. The tenders are to be sent to the clerk, endorsed "Electric Lighting Tender," by the date stated.

Maidstone.—In accordance with the decision of the Local Board the Electric Lighting Committee have made enquiries in various quarters as to the terms upon which private firms or companies are prepared to carry out the installation of the electric light in Maidstone, and have received five offers. These were considered at a recent meeting, but no definite decision was arrived at, further information on certain points being deemed necessary.

New Installations at Liverpool.—Messrs. Bennett and Druce, 44, Fishergate, Preston, have lately completed an electric light installation at Messrs. Glazebrook and Rigby's, of Liverpool, including the whole of the extensive cellars owned by the firm. They have also wired the new offices of the Liverpool Grain Storage and Transit Company, Limited, and of Messrs. Clunie and Co., for connection with the Liverpool Supply Company's mains.

Tenders Required for Aberdeen.—Tenders are required by the 20th inst. for supplying and fitting up electric wiring and fittings for the Northern Co-operative Company's central premises. Copy of specification, schedule, and litho plans may be had from Mr. John Ferries, secretary, 54, Loch-street, Aberdeen, on receipt of 10s., which will not be returned. Tenders, marked "Tender for Electric Fittings," to be lodged with the secretary by the date mentioned.

Clerkenwell.—At the last meeting of the Clerkenwell Vestry the clerk read a letter from Mr. Sidney Morse, secretary to an electric lighting company, saying his clients desired to have certified copies of the recent resolutions passed by the Clerkenwell Vestry with regard to the extension of time. Because his clients were anxious to carry out the electric lighting in the district, he trusted that the Vestry would be good enough to formally give the extension of time asked. The letter was received.

Barrow-in-Furness.—The "Tea House," Ramsden-square, was lighted throughout by electricity for the first time a few days ago. The installation has been erected by Messrs. W. R. Thornton and Son, electrical engineers, Duke-street. The total light is equal to about 200 lamps, each of 8 c.p. The current is supplied by a "Castle" dynamo driven by a 6-h.p. (nominal) gas-engine. Both engine and dynamo are mounted on the same foundation, and being in the shop window, the machinery makes an effective show.

New Telephone Company, Limited, Manchester.—The third annual gathering of the staff took place on Friday evening last, the 2nd inst. There were upwards of 80 ladies and gentlemen present, including a considerable number of friends. The evening was a most enjoyable one, the songs and recitations given by various members of the staff and friends being much appreciated. The farcical sketch, "Wanted, a Servant," was cleverly performed by five of the lady operators. Dancing was indulged in until an early hour.

Manchester.—At a meeting of the Town Council on Wednesday Mr. Bax expressed a wish to have the electric light supplied to Stretford-road, and asked the chairman of the Gas Committee when that would be done. Mr. J. Brooks said that Stretford-road was at present outside the electric light arrangements, but no doubt as soon as Stretford-road or any other district made a demand for the supply of electricity for lighting purposes, and showed a prospect of a reasonable revenue, the Electric Light Sub-Committee would be prepared to undertake the work.

Grimsby.—An installation is being put up in the Prince of Wales Theatre. When the installation is complete there will be about 300 lights in the building. At present the exterior is illuminated by two arc lamps. The incandescent lamps for ordinary lighting are of 16 c.p., whilst those for lighting up the body of the theatre are equal to 25 candles. The footlights and orchestra jets are electrical, and the appearance and comfort of the theatre generally is much better than previously. The dynamo, fixed by Messrs. King and Co., of Hull, is driven by a 14-h.p. Tangye gas-engine.

Derby.—At a meeting of the Town Council on Wednesday, it was stated that the electric lighting station had been furnished at a cost of £143. 18s. 6d. The tender of Messrs. Siemens Bros., Limited, for additional engines, dynamos, main laying, has been accepted. The committee were not ready with their report respecting the staff required for working the electric lighting station. They had, however, appointed Mr. J. E. Stewart to be engineer and manager at the works, at a salary of £260 a year, and Mr. A. P. F. Moore as assistant engineer, at a salary of £2. 2s. per week. The report was adopted.

Kendal.—The Town Council have received a letter from Messrs. R. H. Fell and Sons, Limited, giving notice that with the approval and consent of the Corporation they proposed to apply to the Board of Trade for a provisional order to supply electricity for lighting and other purposes within the borough. Councillor Jefferys supposed that some time would yet elapse before it would be necessary to take any steps in the matter. The Town Clerk stated that July 1 would be the last day for sending in any applications. He took it as an instruction from the Corporation that at the proper time this application should be placed on the agenda.

Appointments Open.—The Blackpool Corporation, as stated in our advertisement columns, require for the tramways a resident working electrical engineer. The wages are 45s. per week. The person appointed must be a good mechanic, with sufficient practical knowledge to take charge of engines, dynamos, motors, and electrical fittings. Applications, in candidates' own handwriting, stating experience, and enclosing three recent testimonials, to be sent to Mr. T. Loftos, town clerk, before the 19th inst. The Edinburgh Corporation require a resident electrical engineer for the municipal electric light station. Further particulars are given in our advertisement columns.

City of London Electric Light Company.—Subject to the completion of the audit and after making the necessary provision for repairs, maintenance, renewals, and reserve funds, the directors, out of the profits for the year ended December 31, 1893, recommend the payment of the full dividend at the rate of 6 per cent. per annum on both issues of the preference shares of the Company, payable on and after the 23rd inst., carrying forward a substantial balance to next account. The Company give notice that the transfer books and registers of members will be closed for the purpose of preparing the preference shares dividend warrants, and for other business of the Company, from the 10th to the 24th February, both days inclusive.

Edinburgh.—The Electric Lighting Committee of the Town Council have opened the tenders for the works at the proposed central station at Torphichen-street. Between 30 and 40 estimates had been sent in, and these were remitted to a sub-committee for tabulation. On Tuesday, the Lord Provost's Committee of Edinburgh Town Council accepted estimates in connection with the electric lighting station at Torphichen-street, amounting in all to £24,300. The following are the successful offerers: Mr. George Sinclair, Leith, for boilers, etc., £6,042; Messrs. Siemens Bros, for engines, dynamos, pipes, pumps, etc., £15,098; the same firm for switchboard connections, etc., £1,760; Messrs. Crompton, Howell, and Co., London, batteries, £1,400.

Lighting of Bolton.—The Gas and Electricity Committee of the Corporation met last week, when tenders were ordered to be obtained for the supply and erection of two station meters at Lum street works. Notwithstanding the difficulties which have beset work of getting out the foundations for the new electric lighting works on Spa-road, much progress has been made. The circulars sent out by the committee to tradesmen and others asking for an intimation as to whether they wish to have light connected to their premises have not been very extensively replied to. An installation has been fitted up throughout the Town Hall corridors, and as soon as the light is ready the present gas fixtures and globes will be removed and substituted by artistic electric chandeliers.

Swansea.—The large premises of Mr. Brown are lighted throughout by electricity. The lighting has been designed by Mr. Brown with a view to efficiency and economy. The shop floor and windows are lighted by means of eight "Waterhouse" arc lamps of 2,000 c.p. The basement, offices, galleries, and showrooms are lighted by 113 incandescent lamps of 16 c.p., 25 c.p., 32 c.p., and 50 c.p. In addition to the arc and incandescent lamps used in the shop, there are two 6,000-c.p. lamps, one of which is underneath the glass roof and immediately over the well-holes in the shop and showroom floors, the other being run in the tower over the front entrance. The tower on the rear of the building has been specially erected to receive a powerful search-light projector of Admiralty pattern. The current for running the arc and incandescent lamps is generated in an engine-room in the basement. The plant consists of a Stockport gas

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engine, of 16 b.h.p., driving an Elwell-Parker compound-wound dynamo.

Dublin.—The Corporation have deferred the consideration of the following resolution: "That the members now constituting the Electric Light Committee, with one member taken from each ward, not now represented on the Electric Light Committee, do constitute for the year 1894 a committee to be called 'the Lighting Committee'; that all the duties and powers of the Paving and Lighting Committees, of the Electric Light Committee, and of the Special Gas Committee, with respect to lighting, be transferred to and vested in the Lighting Committee; that the said committee may keep separate accounts and separately manage the electric lighting and the gas lighting, and report to Council at least once in every three months; that the members now constituting the Electric Light Committee shall co-opt to the Lighting Committee one of the members for each ward not now represented on said committee."

Lighting of the Guildhall.—At a meeting of the Court of Common Council a motion was proposed for the payment of the following bills to Michaelmas last—viz., the Gaslight and Coke Company, £160. 3s. 9d., and Mr. C. B. Ingram (for timber) £188. 2s. Mr. Morton asked for an explanation of the fact that, in spite of the introduction of electricity at Guildhall, the gas bill was so enormously high. Not getting a satisfactory answer, the hon. member moved that the bill for gas should be referred back to the committee for further consideration and report. Mr. Sayer having seconded this amendment, the City Surveyor explained that, although the electric light had been introduced at Guildhall, most of the offices were at the present time lighted by gas, the account for which was about £50 less than that for the corresponding period last year. Payment of the account was then ordered, Mr. Morton's motion being rejected.

The Steel, Iron, and Engineering Trades—In the trade report for 1893 issued by Messrs Bolling and Lowe, of 2, Laurence Pountney-hill, E.C., the following appears: "Another year has passed which has been a very disastrous one to many financial institutions in this country, as well as in Australia, the United States, and Southern Europe; in addition to this a revolution has occurred in Brazil—all of which has affected our trade to a vast extent. The steel, iron, and engineering trades have had to bear their share as the few following figures will show: Quantities and values of steel and iron exported for 12 months ending December 31, 1891, amounted to 3,240,146 tons, value £26,877,000; December 31, 1892, amounted to 2,739,279 tons, value £21,765,768; and December 31, 1893, amounted to 2,857,743 tons, value £20,614,155; but it is to be hoped that the year just commenced may see an increased demand upon our productive powers, and there are signs of this in the gradual recovery in the prices of all classes of pig iron, and in the fact that stocks of this article are comparatively insignificant."

Bristol.—St. George's Local Board have met to consider a Bill now being promoted in Parliament, entitled "A Bill to Authorise the Bristol Tramways and Carriage Company, Limited, to make Additional Tramways, and to Confer Further Powers upon the Company." The Chairman mentioned that as the Bristol Tramways Company were desirous of pushing on with their Bill, the meeting was convened with a view to furthering the matter. They had the Bill before them, but he hardly thought it worth while to read it, as the members knew pretty well the contents. They might depend upon it that Parliament would only sanction such conditions as would be compatible with the public interest. They were aware that in the Bill the tramways company sought powers to work an electric tramway through the parish of St. George by overhead wires. He moved that the Board give their consent to the Bill. Mr. Verrier seconded the motion, which was put and carried unanimously. The Chairman said the next matter to consider was if the Board would permit the trams being worked by overhead electrical wires. He moved that such consent be given. Mr. Coole seconded the resolution, which was carried. The Kingswood Local Board have passed similar resolutions.

Lighting of the Strand.—A long and exhaustive report was presented last week to the Strand Board of Works by the surveyor (Mr. A. Ventris) on the public lighting in the Strand district. He stated that he had made a careful survey of the streets and courts of the district, and was of opinion that the general lighting power of public lamps in the district compared unfavourably with the lighting power of adjoining and possibly less important districts. It was extremely difficult, without a considerable rearrangement, to suggest any increase in the number of lamps, and, moreover, an alteration in the position would give great dissatisfaction to those occupiers who had lamps now opposite their doorways; the removal would, in addition, involve disturbance of pavements, and a considerable expense in restoring them. An increase in the lighting power of existing lamps seemed, as a consequence, to be the only practical method of meeting the demand for more light. It was stated that improved lanterns gave, per feet of gas consumed, a greater light than was obtained in those of the old parish pattern, and those in use in the Board's district were possibly of the oldest type in London. He was unable to recommend, under the present system of supply, the extensive purchase and repair of costly lanterns. The gas company were at first unwilling to let, except on the hire-purchase system, the lanterns that they used, but now they had agreed to waive that objection and let them on the present scale of charge, if the Board would take them for seven years. With the present experience of electric lighting for narrow streets, its cost, and in his judgment its comparative failure for outdoor lighting, he apprehended that latter requirement was one to which the Board would offer no serious objection. It was agreed to remit the report and the whole question of lighting to the committee for further consideration and report.

Birmingham.—As mentioned in our last issue, the Market and Fairs Committee of the Town Council have for some time past had under consideration the subject of improving the lighting of the Market Hall. Messrs. Henry Lea and Thornbery, electrical engineers, have prepared a scheme for the lighting of the interior of the hall by means of 32 arc lamps of two sizes, of about 3,000 c.p. and 2,000 c.p. respectively, the several entrances to the hall being lighted by eight lamps of 2,000 c.p. each. From the result of the experiments made, the committee believe this number of lamps will be ample for properly lighting the hall and the several approaches thereto. The present cost of gas-lighting is about £535 per annum, and, with the additional overhead lanterns, the cost would be increased by about £65, making a total of £600 per annum, exclusive of the cost of lighting the exterior of the hall. The cost of providing and fixing and wiring for the above 40 arc lamps is estimated at £1,000, which sum could be borrowed probably for 10 or 15 years. The annual cost of the scheme would be as follows: Cost of providing and fixing and wiring 40 lamps, £1,000; interest and sinking fund, say, for 10 years, £120; electric light, £380; carbons, £25—total, £525 per annum. The cost of lighting the hall by electricity will therefore be less than the cost of lighting by gas, with far more satisfactory results. The committee have recommended that the scheme for the lighting of the Market Hall by electricity should be adopted, and that the Finance Committee be instructed to borrow £1,000 for providing the necessary lamps and fittings.

Extensions at Blackpool.—On Tuesday the Electric Lighting and Tramways Committee recommended the Council to borrow £24,000 for further extensions in the electric lighting of the borough. Councillor Pearson, in moving the adoption of the minutes, said the committee did not intend to spend the whole of the money in extensions. Three or four thousand pounds of the sum was wanted to pay for the over-expenditure on the last estimates. The committee proposed to spend immediately £15,000, and for future expenditure £5,000. The reason the estimates were exceeded was that a large stock of meters was purchased, and the lamp-posts on the promenade, instead of costing £9, had cost £11 each. A quantity of cable also made up the overspent estimates. Mr. Hammond had presented a lengthy report on the proposed increase in the electric plant. He called attention to the increased consumption and the lessened cost of production, and quoted figures to strengthen his argument. The results of the works had far surpassed the expectations of the committee. Councillor Fergusson seconded. Councillor Bickerstaffe proposed that the whole question of electric lighting be referred back to a meeting of the General Purposes Committee. They were given to understand that for an expenditure of £26,000 they would have a plant which would last them for a long time to come. He then went on to criticise Councillor Pearson's figures, and said that the loss on the actual work was £216, and no allowance had been made for repairs, rates, sinking fund, etc. Electricity was going to be a losing concern at Blackpool, seeing that the price was only 4½d. per unit, whilst in the large cities it was not less than 6d. per unit. Councillor Wildman seconded, and considered that the matter should be left over for 12 months. In reply to a long discussion, Councillor Pearson said the reputation of the town was at stake. He appealed to the Council to adopt the recommendations. The amendment was lost, and the original motion was carried.

Lighting of Chelmsford.—Some discussion took place last week at a meeting of the Town Council concerning the provisional order which Messrs. Crompton are applying for, and the draft of which has been considered in detail at two previous meetings. It appears that the town clerk had received a letter from Messrs. Deacon, Gibson, and Metcalf, solicitors acting in the matter for Messrs. Crompton, in which they declined to make the suggestions made by the Council on the terms of purchase, and submitted an amended draft, the effect of which was that if the local authority purchased at the expiration of 21 years, they should take such parts of the undertaking as were exclusively used for the public lighting of the town as a going concern, and not under the provisions of the Act. If the period of purchase was extended to 31 years, then the purchase must be as a going concern, without any compensation for compulsory purchase, and in the event of the term being extended to 42 years, the purchase would, of course be under the provisions of the Act. The Mayor suggested that a small deputation should wait on the Board of Trade to discuss this matter of the purchase clauses with Messrs. Crompton's representatives, but Councillor Britton remarked that at the previous meeting the Council had agreed to leave this matter in the hands of the Board of Trade. He did not favour the idea of a deputation, for it was divided on the subject, and therefore he desired that they should discuss the matter that evening, and he moved that the amended clauses as submitted by Messrs. Crompton should be accepted. Councillor Tanner agreed with Mr. Britton, while Councillor Taylor, in supporting the motion, said he failed to see what good could come of sending up a deputation to London which might misrepresent the intentions of the Council. Mr. Fawkes supported the motion, but Alderman Chancellor opposed it, arguing that the Council should have the right to purchase the concern at the end of 21 years or 31 years under the provisions of the Act. Councillor Whitmore approved of the amended clauses, and regarded them at reasonable. The motion was carried by a substantial majority. At a later stage in the proceedings Alderman Chancellor submitted that the resolution which had been adopted

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was illegal, in view of the fact that it practically rescinded a previous resolution. Mr. Chancellor's objection was ruled to be in order, and the resolution in question was declared invalid. The matter was accordingly adjourned to the next meeting.

Messrs. Vaughan and Brown.—This firm, of 15, 16, and 17, Kirby-street, London, E.C., have every reason to be satisfied with their past year's record in the electric lighting department. They commenced the year well with Dr. Waugh's mansion, Wimpole-street, W.; Messrs. Faulkner's tobacco factory, Blackfriars-road; the Salvation Tavern, Newgate-street, and the Cambrian Stores, Glasshouse-street, W. They soon had these jobs under weigh and quickly disposed of, enabling them to turn their attention to the Blue Posts Hotel, Tottenham Court-road, and Challis's Hotel extension, The Tottenham, close to the Oxford, and The Chandos, coming in rapid succession. About this time they commenced the Hotel de Provence, a building at the corner of Leicester-square. This was only completed and opened a few months ago, many splendid fittings being specially designed for this building. The firm also installed the gas and the whole of the hot-water apparatus. Towards the summer Messrs. Vaughan and Brown were engaged on The Old King's Head, Old Jewry, the Horseshoe Hotel, Tottenham Court-road, and Old Paris, at the Earl's Court Exhibition, this proving a very successful job. The search-light used in the storming of the Bastille was supplied by them. At the Eastern Empire Theatre, Bow, an installation of about 600 lights was put in, together with a fine plant with 36-h.p. effective gas-engine. This was scarcely finished when they secured the contract for the Paragon Theatre, Mile End-road. This installation consists of about 1,000 lights, and is arranged with two complete plants, each with a 32-h.p. effective gas-engine. The engine-room had to be specially built, and this was done by Messrs. Vaughan and Brown, together with the hot-water heating, and the whole installation was executed in 25 days from the date of order. Following this came The George and Dragon, Shaftesbury-avenue; Messrs. Wylson and Longs, King William-street, Strand; The Duke of York, Germain-street, W.; the lighting of the Brewers' Exhibition, with 40 arc lamps, was next secured, with all the necessary plant for driving same, which consisted of a 50-h.p. gas-engine, dynamos, etc. More arc lamps being required at the Oxford, these were erected on the front of the building with excellent effect. Palace-chambers, Buckingham-gate, and the Confectioners' Exhibition, with 35 arc lamps and a 50-h p. gas plant, were next brought to a successful issue. Messrs. Harrod's stores new dining-rooms next claimed their attention, where some most handsome ceiling fittings were erected, and the large and extensive new offices of the company being entrusted to their care. The Stanley Show and Exhibition, with 50 arc lamps and a 50-h.p. gas plant, and the New Empire Theatre, Bristol, followed with 1 000 lights. Whilst engaged on this work they secured the lighting of The Don, a large clothing establishment in Bristol, with arc lamps. Then came the Cattle Show, with 55 arc lamps, and all the plant, including 50-h.p. gas-engine and dynamos. Great credit in carrying out the various installations is due to their superintending electrical engineer, Mr. G. C. Vaughan, jun., A.M.I.E.E.

Lighting at Leicester.—A special meeting of the Town Council was held on Monday for the purpose of considering the report of Mr. A. Colson, engineer of the gasworks, on the tenders received for the supply of engines required in connection with the electric light station which is being erected at the gasworks, and to which reference was made in our last issue. Mr. Colson, in his report, says: "On December 15, 1893, 10 firms were invited by the Gas Committee to submit tenders for the supply and erection at their central station, Aylestone-road Gasworks, of four horizontal compound condensing engines, three of which were to be of 300 brake horse-power each, and the fourth of 112 brake horse-power. The specification under which the designs for these engines were to be prepared stipulated that 'the governor must be capable of regulating the speed of the engine, so that without any adjustment by hand, whilst working, the speed at full load shall not be more than 3 per cent. less than with no load.' While complying with the conditions of the specification, the competitors were to submit what they considered the best mechanical arrangement for the purpose. Of the 10 firms invited, three declined to tender for reasons given. One tender was received too late for consideration. The tenders of the remaining six firms were opened by the Gas Committee on the 8th inst., and submitted by them to the Electric Lighting Sub-Committee for their consideration and report. At a meeting of the sub committee on January 10, I presented an analysis of the tenders received. Previous to the meeting I informed the chairman that after examining the drawings, specifications, and tenders in conjunction with the engineer of the Brush Electrical Engineering Company, there were in my judgment only two designs suitable for our purpose—viz., the design of Messrs. Musgrave and Sons, of Bolton, which provided engines for a total of 1.180 i.h.p., at the sum of £5,363, and an alternative design of Messrs. Hick, Hargreaves, and Co., also of Bolton, for engines equal to 1,185 i.h p., at the sum of £4,695. The tender of Messrs. Musgrave and Sons was exclusive of labourers required for the erection of the engines; the firm undertaking to supply skilled labour only, and that at a charge of 2s. 6d. per man per day extra to the amount of their tender. I strongly recommended the acceptance of the tender of Messrs. Hick, Hargreaves, and Co. as being the lower of the two. In going through the analysis of the tenders with the sub-committee, the chairman was pleased to refer in favourable terms to the design submitted by Messrs. Jessop and Son, of Leicester. This design, though good in many respects, I had been compelled to reject with others. In an accompanying letter Messrs. Jessop and Son stated: 'We have shown the engines with the dynamo placed between them, being the best way of distributing the strains, and the neatest arrangement. If, however, it is found necessary to apply the power at one end of the dynamo shaft, we can arrange our engines accordingly.' As it was not clear to the sub-committee whether the alternative design was offered at the same price, the firm was communicated with by telephone, and upon their replying in the affirmative, permission was given them to submit drawings of their proposed rearrangement. It is this design and tender marked No. 9 in the analysis, as compared with that submitted by Messrs. Hick, Hargreaves, and Co., and marked No. 7, that I have your instructions to report upon. In general arrangement the designs are similar, inasmuch as side by side engines, placed on one side of the dynamo, are provided for in each case. As to the large engines, they are equal as regards diameter of cylinders and length of stroke, but those offered by Messrs. Hick, Hargreaves, and Co. are to indicate 350 h.p. each, at a cost of £3,945, while those offered by Messrs. Jessop and Son are to indicate 340 h.p. each, at a cost of £4,035. In the former case the engines would be supplied with Corliss valves and gear, and in the latter with Collmann's. Even without claiming any advantage for the additional indicated horse-power this comparison shows a difference of £90 in favour of Messrs. Hick, Hargreaves, and Co.'s tender, added to which the engines are supplied with a more costly and well-proved valve gear. The following are the particulars as regards the small engine offered by each firm:

Firm.	I.H.P.	Revolutions.	Size of cylinder.		Stroke.	Description of valve gear.	£
			in.	in.	in.		
Hick, Hargreaves, and Co.....	135	118	11	20	24	Corliss	750
Jessop and Son ...	125	118	10	18	24	Hartnell	610

From this comparison of the small engines there appears to be an advantage of £140 in favour of Messrs. Jessop and Son, but this amount would be more than equalled by the gain of the additional horse-power, and the extra value and superiority of the valve gear provided for in the engine offered by Messrs. Hick, Hargreaves, and Co. I am thoroughly acquainted with the character of the work executed by each of the firms referred to, and after giving the most careful further consideration to this matter, I am bound to advise you (as I have already advised the Electric Lighting Sub-Committee and also the Gas Committee) to accept the tender of Messrs. Hick, Hargreaves, and Co, as by so doing you will be obtaining greater value for your money, and will be entrusting a difficult and responsible piece of work to one of the most experienced and competent firms of engineers in the kingdom. In conclusion, I may be permitted to point out that the Gas Committee, in adopting slow-speed direct-acting machinery in connection with their electric lighting station, are following continental rather than English practice, and that the successful working of this system abroad has only been achieved by the use of engines of the most perfect design and workmanship." Correspondence and the analysis referred to are appended to the report. On the presentation of the report, considerable discussion ensued. Alderman Lennard moved that the tender of Messrs. Hick, Hargreaves, and Co. for the erection of electric light engines at the sum of £4,695 be accepted, and that the contract be sealed with the common seal of the borough. Councillor Faire seconded the motion. Councillor Marshall moved as an amendment that Messrs Jessop's tender be accepted. Councillor Woolley seconded the amendment. Eventually the amendment was lost and the motion was adopted.

Newport Electric Lighting Scheme.—The following letter, under date January 27, has been addressed to the Newport town clerk by Messrs. Crompton and Co.: "Following on yesterday's visit of your committee to our Chelmsford works and to the Kensington lighting station of the Kensington and Knightsbridge Company, we beg to offer some remarks, which we think should be laid before your committee at the present time. We tendered to your specification for the supply of high-pressure electric plant for Newport lighting, and our tender for the complete plant was the lowest of those sent in. Certain objections were raised by your committee, acting on the advice of their engineer, which were to the effect that our tender, though apparently lowest in cost, did not offer plant of equal value for the intended purposes to that of one of our competitors. We have endeavoured to meet these objections by showing you that there is no foundation for them, that not only have we had considerable and very satisfactory experience in the manufacturing and in the working of high-pressure plant, but that the financial results of our Chelmsford undertaking are equal to, if not superior, to the most successful high-pressure installation which has been at work for a sufficient time to enable a fair judgment to be made as to its efficiency and working cost. On these grounds we beg your committee to reconsider their proposal to pass over our tender in favour of one which involves a greater expenditure of your money. If we are successful in this, we are confident of supplying you with plant which will compare favourably in every respect with any lighting plant that has hitherto been set to work on the high-pressure system. We have gathered from our conversation with the various members of your committee that you are under the impression that we, as engineers, are in complete agreement with your committee's decision to adopt high-pressure lighting, and that your engineer claims that he has converted Mr. Crompton to his way of thinking. We most emphatically deny this. We have never been called upon to express an opinion on this point; we have confined ourselves solely to offering you the best plant required by your specification. As we understand that our silence on this point may be misconstrued, we now beg to state

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that from the very first we have formed an opinion that the area to be lighted at Newport is not sufficiently extensive to warrant the use of high-pressure plant, which is admittedly more costly to work. We feel confident that there will not be any saving, even in capital expenditure, by the adoption of the high-pressure system, and the works cost in such a town as Newport will be 50 per cent. higher on the high-pressure system than they would on the low-pressure one; now that we have visited Newport several times, and walked over the ground and examined the maps of the streets which you propose to light, we are prepared, if we were asked to do so by you, to submit a proposal to design and construct plant on the low-pressure system for a sum which, exclusive of buildings, would not exceed £19,500, and thus would involve a capital expenditure £3,000 less than that which you now contemplate. Our proposal would also include estimates or schedules for extensions throughout the whole of the area included in your provisional order. Further than this, in such a case we should be prepared to take upon ourselves all risks and responsibilities regarding the cost of working these works for any term of years that you may desire. One method of doing this is based upon a sliding-scale of prices at different rates of output, and we enclose a sliding-scale at which we should be ready to work in Newport. Examining this scale you will see at even a very moderate output, apart from the public lighting, of say 100,000 units per annum, there would be a fair margin, after allowing for interest and redemption fund, for the Corporation between the price we ask and the price the Corporation would easily obtain; we consider that in Newport 6d. a unit would be a fair price to charge. Under this scheme, therefore, the town would be relieved of responsibility of working or risk of loss, and yet would own the works, and could thus avoid the possibility of the electric supply becoming a monopoly; they would also be actually receiving profits from the electrical undertaking. We have mentioned above an output of 100,000 units per annum, because we are sure that such a demand will be rapidly and easily reached in Newport probably within 12 months from starting. The second method is: (1) We contract for the necessary works for you as proposed above at £19,500, with schedules for extension; (2) we pay you as annual rental for the use of the works a sum equal to the interest that you have to pay for the money expended thereon; (3) also such further sum per annum as it would be necessary to put aside as a sinking fund to clear off the loan for the electric works in the time which is covered by the provisional order; (4) also we undertake to give up 10 per cent. of the profits which we may succeed in making annually; (5) also we undertake to give special terms for the current required for public lighting. It is, of course, understood that we should be able to give substantial guarantees of our financial ability to carry out our part of the arrangement, and that the Corporation would have the right to terminate the lease of the works to us at any time after a certain fixed period by giving sufficient notice of their intention. We have had little time since our conversation of yesterday evening to formulate these proposals, but we think that we have said enough to put clearly before you what are our views, and what are the responsibilities that we are prepared to undertake, and to show you that we are prepared to support our opinion on commercial lines. Should either of these suggestions be approved by your committee in principle, we shall be glad to meet them and discuss the approved scheme in regard to details, many of which would want carefully considering. Awaiting the favour of your reply, we remain, yours faithfully.

Sliding-Scale.

Quantity.				Rate per unit in pence.	Annual sum.
Exceeding	90,000	up to	100,000	3·8d.	£1,584
,,	140,000	,,	150,000	3·1d.	1,938
,,	190,000	,,	200,000	2·7d.	2,250
,,	240,000	,,	250,000	2·40d.	2,500
,,	290,000	,,	300,000	2·2d.	2,750

N.B.—Intermediate prices can be filled in when desired."

PROVISIONAL PATENTS, 1894.

JANUARY 29.

1886. **Improvements in switches and automatic movements for use in connection with telephones.** Henry Marrian, 5, Maygrove-road, Kilburn, London.

1903. **Improvements in or relating to electrodes.** Marcel Wuillot, 323, High Holborn, London.

1919. **Improvements in telegraph relays.** Charles Langdon-Davies, 24, Southampton-buildings, Chancery-lane, London.

JANUARY 30.

2007. **An electric switch.** The Edison and Swan United Electric Light Company, Limited, and Charles Faraday Proctor, 28, Southampton-buildings, Chancery-lane, London. (Complete specification.)

2048. **Improvements in dynamometers.** Richard Voigtländer, 47, Lincoln's-inn-fields, London. (Complete specification.)

JANUARY 31.

2104. **Improvements in electric switches to be used in conjunction with contacts for continuous ringing.** George Jacob Gurl, 84, Mitcham-road, Croydon.

2105. **Improvements in arc lamps.** Frederick Brown and Charles H. Offord, Fairyfield, Highgate, Walsall.

2112. **Improvements in electric lampholder switches and the like.** Thomas Hugh Caley, 55, Market-street, Manchester.

2118. **Electric light improvements.** Vincenzo Fabris, 1, Netley-street, Hampstead-road, London.

FEBRUARY 1.

2203. **An improvement in electric candle lamps.** Godfrey Durlacher, Auguste Lacoste, and William Lowry, 28, Southampton-buildings, Chancery-lane, London. (Complete specification.)

2211. **Improvements in microphones.** Sir Charles Stewart Forbes, Bart., and the Domestic Telephone Company, Limited, 21, Finsbury-pavement, London.

2217. **Improvements in dynamo-electric machines.** Henry Chitty, 5, Bolton-gardens, Chiswick, London.

2250. **Improvements in galvanic batteries.** Otto Hund, 54, Fleet-street, London. (Georg Wehr, Germany.)

2251. **Improvements in galvanic dry batteries** Otto Hund, 54, Fleet-street, London. (Georg Wehr, Germany.)

FEBRUARY 2.

2262. **Improvements relating to electroliers and ceiling roses for same.** Alfred Ashby, 1, Furnival-street, Holborn, London.

2274. **Improvements in the means for electrically propelling tramcars and other vehicles and the apparatus therefor.** Percival John Pringle, Morningside, High view-road, Sidcup, Kent.

2321. **Improvements in or connected with dynamos.** William Edward Yates and Alfred Clegg, 33, Chancery-lane, London.

2332. **A method of hauling by electricity and apparatus for that purpose.** Fritz Bernard Behr, 28, Southampton-buildings, Chancery-lane, London.

FEBRUARY 3.

2366. **System of underground electric traction.** James Esau Palmer, 215, Bristol-road, Edgbaston, Birmingham.

2424. **An electric locking device for door locks.** Demetrius de Mito, 37, Chancery-lane, London.

2437. **Improvements in and relating to electric time alarm and synchronising apparatus.** Alfredo Antonio Cardosa e Bastos, 45, Southampton-buildings, Chancery-lane, London. (Complete specification.)

SPECIFICATIONS PUBLISHED.

1883.

3116*. **Telephonic circuits.** Pitt. (Amended.)

1890.

4384 **Plates for secondary batteries** Pitken and Holden. (Amended.)

1892.

18039. **Electrolytic cells and diaphragms.** Hargreaves and Bird.

1893.

583. **Electric meters.** Wright.

1355. **Electrothermal plates, tubes, etc.** Forbes.

1539. **Arc lamps.** Pfluger.

2010. **Electricity meters.** Scott.

4691. **Battery elements.** Lithanode and General Electric Company, Limited, and another.

4793. **Electric bells.** Brooke.

6605. **Diaphragms for use in electrolytic processes, etc.** Parker.

6723. **Electric conductor coverings.** Snedekor.

14087. **Incandescence lamps.** Lake. (General Electric Company.)

16008. **Multiple telegraphy.** Piedfort.

19410. **Rendering electrical fittings luminous in the dark.** Firth and Ashwell.

22255. **Signalling by electric lamps.** Fitzpatrick. (Broughton Telephotos Company.)

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	2⅜
— Pref.	—	2¼
Charing Cross and Strand	—	5
City of London	—	11½
— Pref.	—	13½
Electric Construction	—	1⅜
House-to-House	5	2
India Rubber, Gutta Percha & Telegraph Co.	10	22½
Liverpool Electric Supply	5	6¼
	4½	5⅜
London Electric Supply	5	1
Metropolitan Electric Supply	—	8⅜
National Telephone	5	4⅜
St. James', Pref.	—	8¼
Swan United	3½	3⅛
Westminster Electric	—	5½

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NOTES.

Guildford.—The lighting question has not yet been definitely settled.

Telephony.—A scheme is on foot for connecting Vienna and Odessa by telephone.

Dance.—The engineering staff of the Blackpool Corporation electricity works have just had a successful "hop."

Glasgow Tramways.—The tramcars which will be taken over by the Corporation in July are to be lighted by electricity.

The "Pall Mall Gazette" and Mr. Harness.—Mr. Harness has withdrawn his action for alleged libel against the *Pall Mall Gazette.*

Iron and Steel Institute.—It has been decided to hold the autumn meeting of the Iron and Steel Institute at Brussels from September 4 to 7.

Madras Electric Tramways.—It is stated by a Madras paper that friction has arisen between the directors and some of the local shareholders.

Paddington.—A special committee has been appointed by the Paddington Guardians to consider and report upon the proposal to light the infirmary by electricity.

Harbour-Lighting.—The Rothesay Harbour Trust and Town Council have authorised a committee to take steps as might be necessary for lighting the harbour with the electric light.

Acton.—The Local Board have instructed the surveyor to make enquiries as to the probable cost of having a system of electric fire alarms and electric calls for the firemen established in Acton.

Obituary.—Mr. John Galloway, head of the firm of engineers now known as Galloways, Limited, died on Sunday night, in his ninety-first year. He was regarded as the "father of the iron trade" in the Manchester district.

Lighting in Westminster. — The Westminster Electric Supply Corporation, who in December, 1892, supplied current to an equivalent of 98,686 lamps of 8 c.p., are now furnishing 134,268 lamps, and applications have been received for over 9,000 more lamps.

Students of the Institution.—A students' meeting of the Institution of Electrical Engineers will be held this (Friday) evening at 28, Victoria-street, Westminster. Discussion will take place on Prof. Forbes's paper on "The Electrical Distribution of Power from Niagara Falls."

Society of Arts.—On Tuesday, at 8 p.m., a paper on "The Arts and Industries of Belgium and the Antwerp Exhibition, 1894," by M. Edouard Sève, will be read. On Wednesday, at 8 p.m., Mr. W. H. Preece, F.R.S., will present a paper on "Electric Signalling Without Wires."

Private Bills.—In addition to the numerous private Bills by railway companies and other corporations which have been deposited in Parliament, it is mentioned that 17 water companies, five gas and water companies, and 16 gas and electric lighting companies are asking for further powers.

Chiswick.—The Local Board have received communications from the Board of Trade in reference to the amendments suggested by the Board as to the proposed regulations for electric lighting in Chiswick. The Board of Trade has substantially adopted the opinion of the Local Board and the surveyor.

Missenden.—The village of Missenden, Bucks., was illuminated by electric light on Tuesday evening, the Vestry having entered into agreement with an electric lighting company to light the streets during the winter months This is the first place in the county that has adopted the electric light for street illumination.

"British Locomotives."—The first edition of Mr. Bowen Cooke's work on "British Locomotives" has sold so rapidly that the publishers announce a second and revised edition as almost ready for issue. The same publishers (Whittaker and Co.) announce a work on "Surveying and Surveying Instruments" by Mr. G. A. T. Middleton.

"Electric Light Installations."—The second volume of Sir David Salomons's "Electric Light Installations" (seventh edition), dealing with apparatus, engines, motors, governors, switches, meters, etc., will be shortly issued in Messrs. Whittaker's "Specialist's Series." The third and concluding volume is now in the press, and will deal with the application of electricity.

The Institution.—An ordinary general meeting of the Institution of Electrical Engineers will be held on Thursday next, the 22nd inst. A paper by Mr. Gisbert Kapp, M.I.C.E., member, "On a Method of Testing the Magnetic Qualities of Iron" will be read. A "Note on Parallel Working Through Long Lines," by Mr. W. M. Mordey, member, will also be presented.

Lecture.—The next meeting of the Hammersmith Literary and Scientific Society will be held to-morrow (Saturday), at eight o'clock, at the Vestry Hall, Hammersmith Broadway, when Mr. Julius Maier, Ph.D., will deliver a lecture entitled "Disinfection, with Special Reference to Electrolytical Methods for the Purification of Sewage." The lecture will be illustrated by experiments.

Telephony.—The Highways Committee of the London County Council have considered an application made by the Home Telephone Company for permission to place a telephone cable in the subways from 85, Queen Victoria-street to Charing Cross, and along the whole length of the subway in Northumberland-avenue. The committee recommended that permission be given on certain conditions.

Central London Railway.—The shareholders in this company have passed a resolution approving the Bill in Parliament extending the time for the purchase of lands and completing the railway. The Bill proposed that the time for purchasing land in respect of the whole undertaking should be extended to 1897, and until 1900 for completing the works. It is intended to adhere to electricity as the motive power.

Royal Meteorological Society. — An ordinary meeting of the society will be held at 25, Great George-street, Westminster, on Wednesday next, at 8 p.m. Papers will be read on the following: "Temperature, Rainfall, and Sunshine at Las Palmas, Grand Canary," by Mr. J. Cleasby Taylor, M.D.; "Report on the Phenological Observations for 1893," by Mr. Edward Mawley, F.R.Met.Soc.; and "Comparative Observations with two Thermometer Screens at Ilfracombe," by Mr. William Marriott, F.R.Met.Soc.

Lighting of Petroleum Vessels.—In the course of a paper read last week before the Institution of Civil Engineers, on "The Transport of Petroleum in Bulk," Mr. Boverton Redwood, A.I.C.E., stated that the chief risk occurred during loading and discharging. The vessel should, except as regards the necessary marine lights, be lighted only by electric incandescent lamps, the ship being carefully wired, the positions of the switchboards being judiciously chosen, and any lamps used in spaces liable to become charged with vapour being of safe construction.

Station-Lighting.—A further extension of electric lighting has just been completed at the new Caledonian Station, Edinburgh, and the whole of the platforms and offices, so far as they are completed, are now lighted by electricity. Seven arc lamps of 2,000 c.p. have been

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erected in the shunting and goods yard. The goods-sheds, offices, and signal-boxes have also been provided with about 400 16-c.p. incandescent lamps. In the lighting of the station gas has been entirely dispensed with. The work has been executed by the railway company's electrical staff under the supervision of Mr. Dunn, the superintendent of telegraphs.

Exhibition of Meteorological Instruments.—The council of the Royal Meteorological Society have arranged to hold at 25, Great George-street, S.W., from April 10 to 20, an exhibition of instruments, photographs, and drawings relating to the representation and measurement of clouds. The Exhibition Committee invite co-operation, as they are anxious to obtain as large a collection as possible of such exhibits. The committee will also be glad to show any new meteorological instruments or apparatus invented or first constructed since the exhibition in 1892, as well as photographs and drawings possessing meteorological interest.

Laying of New Mains.—The London County Council on Tuesday granted permission to the Charing Cross and Strand Electricity Supply Corporation to lay a 1in. pipe containing pilot wires from the end lateral of the Northumberland-avenue subway to the office of the Boy Messengers', etc., Company in that thoroughfare; to the House-to-House Electric Light Supply Company to place mains in Rosary-gardens on the east side; to the Westminster Electric Supply Corporation to lay mains (*a*) across King-street, Westminster, and (*b*) from the north-west corner of Carpenter-street, along Mount-row, to Davies-street; and to the Crystal Palace District Electric Supply Company to place mains in Sydenham-hill-road from High-street to Eliot-bank.

Electric Traction at Howth.—The proposals to construct an electric tramway on the north side from the terminus of the United Tramway Company at Dollymount to Howth, and on the south side from Clonskeagh terminus to Dundrum and Windy Arbour, show that the people of Dublin are awakening to a full sense of the importance of electricity as a motive power. Their present alertness is, no doubt, due to the fact that the Dublin Southern Tramways Company have succeeded by quietly energetic and businesslike persistency in obtaining parliamentary powers for the construction of an electric railway through the whole extent of their present district from Haddington-road to Dalkey, and as soon as the required capital is subscribed the work will be commenced.

Electric Light in the City.—The City of London Electric Lighting Company report that the street work is now approaching completion. On February 1, 580 miles of "ways" had been laid in the City in 55½ miles of streets, through which 105 miles of cables had been drawn. Sufficient "ways" have now been laid down to supply a demand of 400,000 8-c.p. lamps installed. As regards private lighting, nearly 1,300 private consumers, representing a total of 72,000 8-c.p. lamps, are now being supplied with current from eight transformer stations, and during the current half-year it is expected that the whole 22 stations required for the entire City will be at work. Applications, the directors add, continue to come in satisfactorily, the total received to date being equal to the supply of current for 100,000 8-c.p. lamps.

The Dangers of Electric Wires.—In the House of Commons on Monday, Mr. Weir asked the President of the Board of Trade whether his attention had been drawn to a serious accident which occurred in a public street in Bournemouth, by which one horse was instantly killed and another seriously injured, and the lives of passengers endangered who were in the omnibus to which the horses were attached; whether the accident was caused by a leakage of high-tension electricity from the electric wires laid under the street; and whether steps would be taken to prevent similar accidents occurring in the streets of London. In reply, Mr. Mundella said that the electrical adviser of the Board of Trade was instructed on the day of the accident to make enquiry on the spot. He would be happy to hand to the hon. member a copy of the report which disclosed the inspector's opinion of the probable causes of the accident. The Board of Trade are now considering whether any additional regulations are necessary in order to prevent similar accidents in future.

Traction at Bristol.—The Chairman of the Bristol Tramways Company, Mr. W. Butler, mentioned last week to the shareholders that the directors could recommend the introduction of the overhead trolley system between Old Meeting-street and Kingswood-hill. The accumulator method had been tried probably for the longest time at Birmingham, where one of the sections of the Central Company's system was worked in this way. As the result of a thorough test under the best possible conditions, the system had been found excessive in cost and uncertain. Mr. Butler stated that the authorities representing three-fourths of the length of the route, had already signified their unanimous approval of the Bristol Company's proposals. This had been done after an inspection by the members of the local authorities of a similar installation at Walsall, Darlaston, and Wednesbury, the deputations returning fully impressed with the great advantages which must accrue to their constituents by permitting the company to introduce it in their districts.

Polarisation of Platinum Electrodes in Sulphuric Acid.—Mr. J. B. Henderson, in the *Proceedings* of the Royal Society, refers to experiments in this direction. Of two platinum electrodes immersed in sulphuric acid and connected with the primary circuit, one was also connected with the earth, and the other through a key with one pair of quadrants of an electrometer. Connected with the same pair of quadrants, through another key, was the slider on a bridge with a special battery. The other pair of quadrants and one end of the bridge were earthed. The slider was so moved that the permanent deflection it gave on the electrometer was not disturbed when the primary circuit was broken and the polarised electrodes connected with the instrument. The potential of the quadrants was then that of the polarisation. The mean value of the E.M.F. of polarisation determined in this way was 2·09 volts, the primary current varying from 0·2 to 1·0 ampere, the time of its passing from 25 minutes to 18 hours, and the strength of the solutions from 5 to 30 per cent. The extreme values were 2·05 and 2·14.

Refuse as Fuel.—On Saturday a party, including engineering experts, sanitary officers, and others interested, journeyed to Halifax, at the invitation of the directors of the Atlas Contracting Syndicate, Limited, to see the Livet process of burning rubbish for the production of motive power. The party were received at the works by Mr. Edwin E. Glaskin, C.E., the consulting engineer to the company, in the engine-room, which was lit by several arc lamps, the steam power being supplied by the Livet boiler. Near the furnace doors was a large heap of unsifted refuse. The furnaces were fed solely from this heap, and in spite of its unpromising nature, no smell whatever is said to have been apparent, nor was any smoke visible from the furnace shaft. Details as to the construction and working of the furnace were given by Mr. Glaskin. He said that the average quantity of rubbish burned per hour on each square foot of grate surface was 33lb., and

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four separate tests, made in the presence of independent engineers, show that 4·081b. of water were evaporated per pound of rubbish consumed. The steam generated can be applied to purposes other than electric lighting. The town refuse of London, Mr. Glaskin states, would produce by this process over 87,818 i.h.p. at a total cost of £141,499, whereas the cost with the best Lancashire boiler, burning coal and evaporating 10lb. of water per pound of coal, would be £799,143.

Electric Lighting of Londonderry.—The Corporation have again discussed the scheme for lighting the city by electricity. The cost was originally estimated at £12,000, and was afterwards increased to £15,000, but now, when the works are approaching completion, it has been discovered that £25,000 will not be sufficient to carry out a complete and satisfactory scheme of illumination. The meeting held on the 9th inst. was convened on a requisition sent to the mayor and signed by six members of the Council. Councillor Hastings proposed a resolution that they should get powers to borrow a supplementary loan of £5,000 in order to finish the cost of lighting 170 arc lamps. Councillor Young seconded the motion. The debate was then carried on with great animation, and an amendment was proposed by Councillor Harper, and seconded by Councillor Caldwell, that having regard to the excessive expenditure already incurred in connection with the electric lighting scheme, and having regard to the absence of any reliable information touching same, it is resolved not to apply for any further loan in connection with the scheme. On a division the amendment was lost by 13 votes to 6. Councillor Babington then moved, and Councillor Thompson seconded, a further amendment, that £3,500 be applied for; and on a second division this amendment was also defeated. The original motion, to borrow an additional £5,000, was then put to the Council by the Mayor, and carried by 10 votes for to 8 against.

The Waterloo and City Electric Railway.—When the shareholders of the London and South-Western Railway Company had disposed last week of the ordinary business of the company, the meeting was made special for the purpose of considering *inter alia* an agreement between the company and the Waterloo and City Railway Company, incorporated by the Waterloo and City Railway Act, 1893. Mr. Wyndham S. Portal, the chairman, explained that this was an important matter. The railway, running as it would from Waterloo to a terminus near the Mansion House, would be an immense convenience to persons using the South-Western Railway and having business in the City. There would be no intermediate station, and passengers would be conveyed in the space of about four minutes. He also mentioned the interesting fact that this project had been talked of ever since 1846, but had always been abandoned because the South-Western had never seen their way to get to the City under three or four millions of money. Now science had come to their help, the capital for making the line being estimated at £540,000. It was proposed to raise the money in £10 shares bearing a minimum dividend of 3 per cent. The directors felt certain it would be a remunerative undertaking, and the proprietors of the London and South-Western would have priority in the allotment of shares. In a short time tenders would be invited for the construction of the line, and it was expected that the work would be completed in two and a half or three years. The proposed agreement was authorised to be entered into.

The Removal of Telephone Wires.—Judgment has been delivered by Mr. Justice Kekewich, in the Chancery Division, in the action brought by Keith Prowse and Co., Limited, against the National Telephone Company, Limited. It was a motion on behalf of the plaintiffs to restrain the National Telephone Company, their servants, or workmen from cutting or disconnecting the telephone wires connected with the plaintiffs' premises. From the statements of counsel, it appeared that on July 1, 1889, the defendants entered into an agreement to supply the plaintiffs with telephone communication, the plaintiffs paying a certain rent. That agreement came to an end, but defendants continued to supply the wires, the plaintiffs continuing to pay the rent. On December 30, 1893, the defendants gave the plaintiffs notice to terminate the agreement forthwith, and demanded the rent up to December 31, and gave notice of their intention to disconnect the wires. Plaintiffs then issued the present writ, and gave notice of motion. Mr. Justice Kekewich said as no question arose as to erection of the wires, the question was one of the maintenance. The company might not be compelled to maintain the wires, but it was the essence of the agreement that the wires should be open to the use of the plaintiffs, and the defendants could not be allowed to cut them off. In his Lordship's opinion, by the conduct of the parties a yearly tenancy had been constituted, which the defendants could not be allowed to terminate by an immediate notice. He should grant an injunction to restrain the defendants from interfering with the wires pursuant to their notice until trial or further order, the cost to be costs in the action.

Action of the Electric Arc on the Diamond, etc. M. H. Moissan, in the *Compt. Rend.*, deals with the action of the electric arc on the diamond, amorphous boron, and crystallised silicon. In the electric arc, at a somewhat high temperature, the diamond becomes incandescent, swells up without melting, and becomes covered with black masses consisting entirely of hexagonal lamellæ of graphite, which is easily converted into graphitic oxide. If the diamond is placed in a small carbon crucible in the electric furnace previously described, and is subjected to the action of an arc produced by a current of 70 volts and 400 amperes, the crystal first breaks up into small fragments along the planes of cleavage, and then at a higher temperature swells up and is completely converted into graphite, which yields yellow graphitic oxide. It follows that at the temperature of even a moderately intense electric arc, the stable form of carbon is graphite. When heated in a carbon envelope at the temperature of the oxy-hydrogen blow-pipe, the diamond is covered with an adherent black mass, which slowly dissolves in a mixture of potassium chlorate and nitric acid, but which is not graphite. Amorphous boron, prepared by means of magnesium, volatilises without fusion in the electric arc, the extremities of the electrodes being converted into partially-crystallised boron carbide. Crystallised silicon, when heated in the arc, first melts and then boils, the extremities of the electrodes at the end of the experiment being covered with pale green crystals of carbon silicide. The phenomena in the arc were observed by projecting on a screen by means of an intense arc an image of the arc of lower intensity in which the substances were heated.

The Use of Cupric Nitrate in the Voltameter.—A paper by Mr. F. E. Beach is given in the *American Journa of Science* on the "Use of Cupric Nitrate in the Voltameter and the Electro-Chemical Equivalent of Copper." The object of this paper is to show that cupric nitrate has some marked advantages over the sulphate for use in the voltameter. The nitrate solution freshly prepared has a tendency to dissolve copper, which decreases, however, after the copper electrode has been kept in the solution for a sufficient length of time. Another difficulty is due to oxidation of the copper deposited, which may be prevented by the addition of a small amount of ammonium chloride.

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The following method is recommended for the preparation of the solution: Dissolve copper nitrate, the purest obtainable, in distilled water. Boil for a short time to expel the air, and keep at a temperature of 100deg. for an hour or two in the presence of bright metallic copper in order to completely neutralise the solution. When ready for use it should have a density of about 1·53. Add a saturated solution of ammonium chloride at about the rate of one drop to 100 c.c. of the nitrate. It is not easy to specify the proper amount of ammonium chloride necessary, and the surest way is to try a preliminary experiment. If too much be present, the deposit will discolour on drying; if too little, the deposit will oxidise in the solution. The weight of copper deposited does not appear to depend on the current density, and is practically independent of the temperature between 10deg. and 35deg. The equivalent obtained for copper, using the nitrate, agrees very well with that calculated from the best chemical determinations.

The Society of Engineers.—Mr. George A. Goodwin, the president for the present year, delivered an inaugural address before the society on Monday, dealing with the present position and practice of mechanical engineering. Boilers being the most usual form of apparatus whereby motive power is obtained to put all machinery in motion, he naturally dealt with them first, pointing out rapidly the growth up to the present types—viz., Lancashire, Galloway, marine, locomotive, and water-tube, etc.—and mentioned the chief points in each, both in construction and working, and recommending mild steel of a certain quality, and properly tested for strength, ductility, and temper. Passing on from steam-engines, the author described the many improvements made in internally-fired engines (gas and oil) in recent years, culminating in the use of ignition tubes, self-starters, better thermal efficiency, and larger powers. Electricity followed on, and references made to its various applications, including that for printing the daily and weekly papers when power was only required for short periods per day, saving initial outlay, space, attendants, and firing-up losses. Suggestions were also made that electric light companies should sell current for power purposes at any time of day or night at a reduced charge. Electric, cable, and steam traction were then reviewed, as also the particulars of the systems and costs of working. In conclusion, he gave a few words of advice to the younger members who had elected to follow the profession of an engineer, recommending a sound practical training by day with theoretical study in evenings; to follow up some speciality to the hilt, but at the same time to obtain and maintain a good general knowledge of other branches.

The Finances of the Bradford Central Station. In moving the adoption, on Tuesday, of the accounts referring to the central electric light station during the past half-year, Alderman Moulson gave some interesting figures. He stated that the works were in fairly good order, that the buildings had been completed, the contractors paid off, and the engineer as well. Two engines were ordered last year. One had been doing good service since about the middle of December, and the other would be finished in about a fortnight. The engines were of 200 i.h.p. each. There was still room for other two. During the half-year the sales of electricity came to £5,510 (£4,548 in 1892); hire of meters represented £100 (£79 in 1892). The payments included £1,500 for miscellaneous expenses (£1,204 in 1892); £1,175 for salaries and wages (£793 in 1892); £785 for interest on loans (£719 in 1892); and £827 for sinking fund (£577 in 1892). The total was £4,463, against £3,562 in 1892. The total amount of the capital was £56,679. The total number of lamps connected with the mains, or their equivalent in current, was 28,400. About 2,500 yards of mains had been laid during the six months. There would have been in connection with the electricity works a very good profit had it not been for the coal strike, which had made the coal cost about £600 extra. Alderman F. Priestman, at the close of Alderman Moulson's statement, expressed the opinion that it would be a very great advantage to the committee and the Corporation to reduce the price of electricity to 2½d. or 3d., for motive power only, during the day. He had reason to know that people who were using a considerable amount of current would not go on paying 5d. for it, which was a higher price than they were giving for other motive power.

Lighting at Gothenburg.—The generating station of the Elektron Lighting Company, Limited, at Gothenburg, is on the low-tension three-wire system. The plant consists of two Babcock boilers for a working pressure of 150lb., a fuel economiser, one triple-expansion engine of 300 i.h.p., one of 240 i.h.p., one of 75 i.h.p., and one compound of 75 i.h.p. The dynamos are rope-driven from engine flywheel. The larger ones are of the Crompton type and the smaller by a Swedish maker. The small engines have each their own jet condenser; the large engines exhaust to a common jet condenser worked by direct-acting compound cylinders The boilers work with forced draught, the air being blown into the closed ashpit by an ordinary blast fan worked by separate engine. The cables are all carried overhead on Callender's bitumen system. The lighting embraces 28 1,400-c.p. arc lamps for the harbour illumination, 51 arc lamps for shop-lighting, and some 5,600 16-c.p. and a few 5, 8, 32, and 50 c.p. incandescent lamps for shop and domestic lighting. In addition to these, the station supplies current to some 20 motors ranging from ¼ h.p. up to 8 h.p., aggregating about 45 h.p. The service is constant all the year round. The total output during the past year was 516,117 units. Most of the current being sold by contract and not by meter, an average loss on the cables of 15 volts can be allowed for in order to arrive at the current actually sold. This gives 457,908 units. The total income from the sale of current was £4,544, or 2⅜d. per unit sold. The coal account equalled ⅔d. per unit at dynamo terminals, or $\frac{9}{20}$d. per unit sold. Mr. James G. Calvert, the managing director, states that the consumption of coal amounted to 7lb. per unit sold, and that the net profits for the year, after payment of all interests on loans and all repairs of machinery, were £1,166.

Settlement of the Newport Tender Question.—This matter, which had been referred back to the committee, was decided on Tuesday, when Alderman H. J. Davis brought up the report of the Parliamentary and Improvement Committee, dealing with the question of the electric lighting plant. It was recommended that the original recommendation be adhered to—viz, that the all-round tender of Messrs. John Fowler and Co., Leeds, for the whole installation except the cables, at a sum of £19,797, be accepted, and that the tender of Messrs. Siemens Bros. and Co. for cables, at a sum of £2,896, be accepted. Alderman Davis proposed the adoption of that report and Mr. T. Goldsworthy seconded. As an amendment, Mr. R. Wilkinson moved that the tender of Messrs. John Fowler and Co. be declined; that the tender of the Uskside Company for the supply of engines be accepted, and that Messrs. Crompton and Co. be offered the balance of the contract on the basis of the amount of their original tender, provided they would give Newport firms the offer to make any machinery, pipes, and other work that could be done in the

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town on equal terms. He presented a petition from the Society of Engineers, Steam Engineers' Society, and Iron-founders' Society in favour of the adoption of the course he had proposed. The amendment was seconded by Mr. T. Cordey. A long discussion then took place, and ultimately the amendment was defeated by 20 votes to 5, there being 10 neutrals. Mr. W. H. Brown then moved as a further amendment that the former amendment of the committee be adhered to, to give the tender to Messrs. John Fowler and Co., except as to cables, which were to be given to Messrs. Siemens and Co., and to engines, which should be given to the Uskside Company, of Newport. Mr. E. Griffiths seconded this amendment, upon which there was also a large amount of discussion. Ultimately it was agreed to by a large majority.

The Municipalisation of Electricity Works.—A fortnight ago, as stated in our issue of the 2nd inst., the London County Council referred back to the Finance Committee an application by the St. Pancras Vestry for a loan of £30,000 on the ground that the total initial cost should be extended over a reasonable period, and without regard to the life of any particular portion of that which forms initial cost. On Tuesday, after reconsideration, the Finance Committee reported that they had again given careful consideration to the application of the Vestry for the loan of £30,000 for 42 years on the annuity system. As stated in their former report, the Council had already sanctioned loans for £10,000 for the purchase of one site, repayable in 50 years, and £8,000 for another site, and £60,000 for works, both repayable in 42 years. The loans for £10,000 and the £8,000 for land were advanced by the Council, and that for £60,000 borrowed elsewhere, as the Council had no power at that time to lend for other purposes than the purchase of land for a longer period than 30 years. This restriction was, however, removed by Section 7 (iv.) of the Money Act of 1892, and the term of 50 years fixed as a maximum limit. On July 26 last they reported on the Vestry's application for a further loan of £30,000, when they recommended (having regard to the amount already borrowed and to certain other circumstances referred to in the report) that the loan should be limited to £15,400. The Council concurred in their recommendation that the repayment of that sum should be spread over 42 years. The Vestry had not taken up this loan, and it now renewed its application for the £30,000. Having regard to questions raised since in connection with a depreciation fund for renewals of plant and machinery, the committee felt it their duty to further consider the whole subject of the term for which loans for electric lighting purposes should be sanctioned. They were sensible that the question was one of great importance to the local authorities of London, and they were anxious that the Council should do what was possible to stimulate municipal enterprise, regard being had to the duty placed upon the Council by statute of controlling the borrowing by vestries and district boards. It must not be forgotten that, as the sanctioning authority for loans to vestries and district boards under the Electric Lighting Acts, the Council was charged by Parliament with the duty of protecting the interests of future ratepayers as well as of doing justice to the necessities of the present ratepayers. After full consideration of all the circumstances of the case, they had determined to recommend that a loan of £29,700 should be sanctioned for a term of 25 years. After some discussion, the report and recommendations were adopted. The County Council agreed to lend the Vestry of Islington £9,000 for 55 years for the purpose of purchasing a site for an electric lighting station.

Telegraphy Between England and India.—The members of the Indian Section of the Society of Arts listened last week in the Imperial Institute to a paper read by Mr. E. O. Walker, C.I.E., late of the Indian Telegraph Department, on "Telegraphic Communication Between England and India; its Present Condition and Future Development." The author first described the gradual growth of the Anglo-Indian telegraph service. He next touched upon the tariffs, traffics, earnings, and profits of the lines, with other kindred details. When communication between England and India was first opened, he said, the unit of charge was a message of 20 words for £5, or at the rate of 5s. per word. At the present time from England to India the rate was 4s. *vid* Suez and Teheran, and 3s. 8d. *vid* Turkey. From India to England the corresponding rates were Rs.3 4a., and Rs.2 15a. It would surprise most to know that the total amount paid for telegrams between India and the United Kingdom in 1891-92—namely, £270,000—was only about ¼ per cent. of the value of the total trade—Rs. 95,222,155. He attributed this unnatural restriction of traffic solely to the high rate which prevailed. The inland telegraph traffic in India in the last 20 years had increased from 684,388 to 3,441,637 messages; while that exchanged between that country and Europe had increased from 50,462 to 193,782 messages by all routes. This number, it must be noted, included all Indo-European official, commercial, Press, and domestic messages. Thus, setting the continental traffic aside, India and England only exchanged about 465 messages per working day. This fact, when compared with the volume of their mutual trade and with the enormous political interests common to both countries, spoke for itself. The question next arose, what amount of traffic could be easily carried by the Indo-European and Eastern Companies with their existing lines should the introduction of a reduced rate largely augment the number of telegrams? There was another feature in modern telegraphy by which, without increasing the capital outlay by more than a small sum—£15,000 in the case of the Eastern Company's cables—the carrying capacity of the circuits was almost doubled. This was the "duplex system," which, by special arrangements of apparatus at the ends of a circuit, but involving no alteration of the wire or cable itself, permitted of messages being transmitted simultaneously from each end. Dr. Muirhead's efficient duplex system, which was applied to the Eastern Company's cables some 12 years ago, about doubled the carrying power of a circuit. It afforded means of now dealing, in conjunction with the Indo-European Company, with over 7,000 messages daily. The charge could, and should, be reduced by 6d. yearly until the present rate—4s.—was lowered to 2s. 6d. What was essential to the introduction of a permanently low charge was the extension of the overland systems of telegraphs. There were three links to be completed in these systems, which would, with a properly organised service under central control in connection with the European lines, certainly afford means to India and England of exchanging correspondence far more cheaply than at present. They were as follows: Shiraz to Jask, in Persia, 575 miles; from Mashad to Herat, and thence to Kandahar and Quetta; and from Merv to Herat, *vid* Penjdeh. It was essential to the success of the working of long lines passing through foreign territories that they should be administered by one responsible directorate, and existing circumstances pointed to the Home and Indian Governments, as well as the company that had already achieved such good results, as the authorities best qualified to promote telegraphic enterprise in the localities he had indicated.

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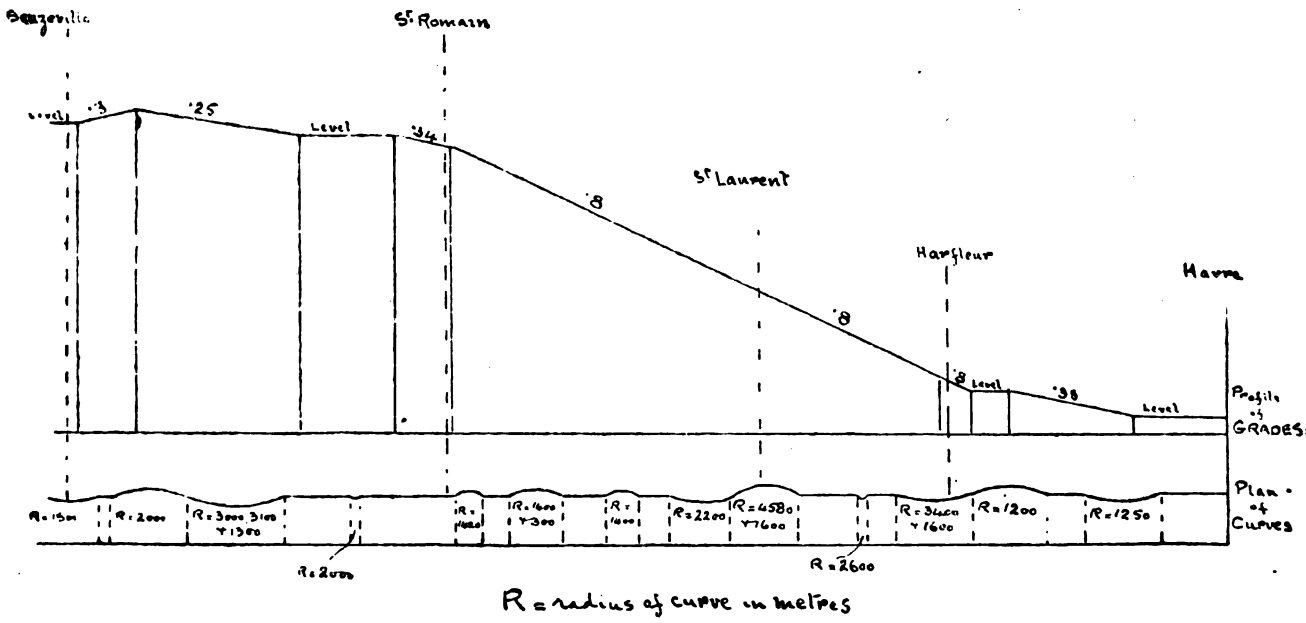
THE HEILMANN ELECTRIC LOCOMOTIVE.

BY FRANK B. LEA.

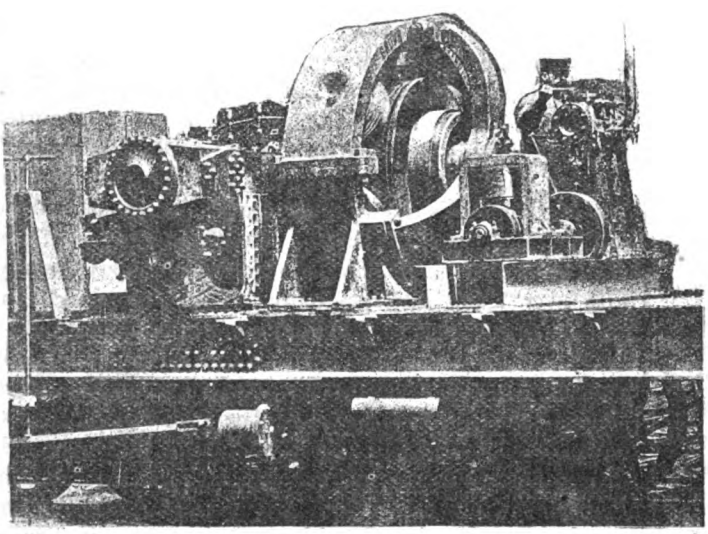
On Saturday last I was enabled, through the courtesy of Mons. J. J. Heilmann, the inventor of the unique contrivance, and managing director of the French company which is developing its use, to join a number of engineers and others interested in the progress of rapid-transit methods in a trial trip of the Heilmann locomotive upon the railway out of Havre towards Paris. Here, along the main lines of the Chemin de Fer de l'Ouest, very successful runs were made between the terminal station at Havre and the village of Beuzeville, about 16 miles distance, this place being chosen as a convenient turning point, so that several trips might be taken in the day. Of course—as will be seen further on—there is no actual limit of the locomotive to any distance so long as coal and water can be obtained.

It seems to be pretty generally admitted that electric locomotives have for such purposes very great advantages over those operated by steam, and the reasons for this are by now so well known and discussed (*e.g.*, the abolition of reciprocating parts—piston rods, side rods, etc., connected to the driving-wheels; the ease with which all wheels may be made drivers, and all the locomotive weight available for adhesion; a lowered centre of gravity; and greater ease in running round curves, due to a shorter rigid wheel base, etc.), that it is hardly necessary even to enumerate them all.

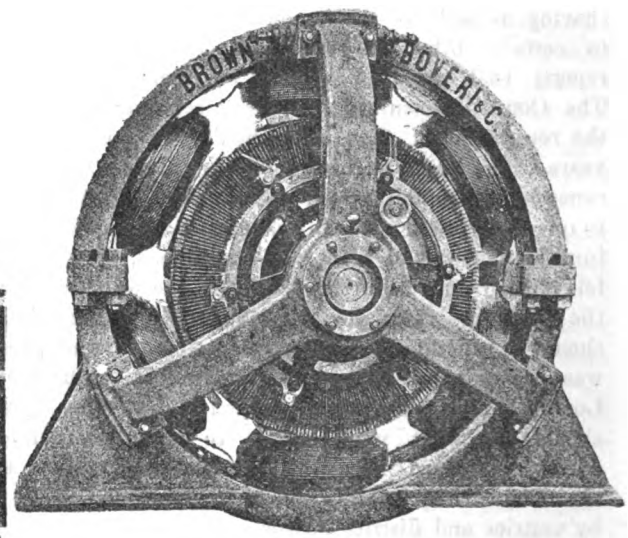


Heilmann Locomotive.—Profile of Line Showing Gradients Per Cent.

The essential feature, however, of the Heilmann design, as opposed to all other electric locomotives, lies in its being wholly "self-contained"; independent, that is, of a generating supply station and line conductors for conveying current, as on the South London and the Liverpool railways. Of course, this very characteristic—the hauling about by each locomotive of its own steam and electric generating plant—appears enough in itself, when first considered, to brand the whole device as being absolutely uneconomical, if not absurd. Why, it is asked, not at once use the steam power for rotating the engine wheels (as in the ordinary locomotive) if a boiler and steam-engine must be carried at all?



Heilmann Locomotive.—View Showing Main Steam Engine, Dynamo Generator, and Exciter.



Heilmann Locomotive.—View of Dynamo Generator.

Details of this locomotive have already been published from time to time in these pages as the work of design and construction proceeded; but this being its first public appearance, a more extended notice ought to be given, summarising its chief characteristics, criticising where necessary the parts not yet fully perfected, and assigning such amount of praise as an unbiassed observer will feel that the device fully deserves.

The main idea of Mons. Heilmann in designing and constructing this locomotive appears to be the provision of better and more suitable means for the attainment of high speeds, perhaps, particularly with light loads—that is, to run at the outset express passenger traffic.

The great additional weight of locomotive, and the extra energy transformation, cannot fail, it has been asserted, to incur a great waste of power and fuel, instead of effecting an economy in it.

On the other hand, Mons. Heilmann claims—quite rightly—that his method of working enables high-speed electric traction to be adopted at once on any line without interfering with present conditions or necessitating expen-

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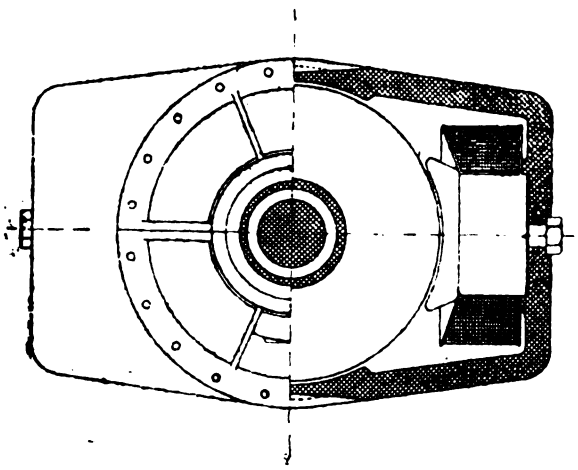
sive changes in the permanent way, or requiring the erection of fixed generating stations whose capacity is practically limited as regards length of line operated, and which at the outset would have extremely small load factors, with consequent lack of efficiency.

The chief difficulty in coming to a decision of any value whatever on the matter lies most in the absence of accurate monetary values which we may assign to increase of train speed and greater safety of travelling. There is no doubt whatever that these latter advantages are worth something to the public who use railways; and if a greater volume of traffic is induced at reasonable rates, a small increase in working expenses might, from the railway manager's point of view, be perfectly justifiable.

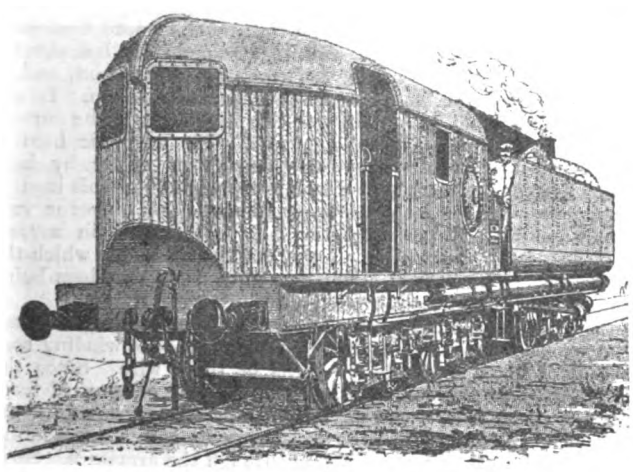
But although I am assuming that the working expenses



Heilmann Locomotive.—Vertical Section through Motor along Truck Axle.

would necessarily be increased on the employment of locomotives after the Heilmann pattern, this is not as yet by any means finally determined; and until the tests just made and carried out by the French railway officials are publicly announced and analysed, it would be unfair to say absolutely that the Heilmann locomotive could never prove economical.

At the present time, moreover, it is practically impossible to persuade any railway company now working a line by steam to change the system so that electric traction shall be wholly, or even partly, employed upon it. The initial



Heilmann Electric Locomotive.—General View.

outlay would prove so great that all interested persons might well shrink from discussing the change, and still more from actually carrying it out.

In April last some details of the locomotive were published in the *Electrical Engineer*, and these, repeated with some illustrations, will show its leading features. The description ran thus: "The boiler and generating machinery are carried on a frame, 53ft. long, which rests on two eight-wheel bogies. On either side of the boiler are coal-bunkers having a total capacity of six tons, and water-tanks for 2,200 gallons. The total power of the locomotive is from 600 h.p. to 800 h.p., and its weight, when in service, 42 tons. The boiler is of the Lenz type; length over all, 26ft.; diameter, 6ft. 4in.; grate surface, 24·5 square feet; heating surface of firebox, 200 square feet; heating surface of tubes, 1,400 square feet. The engine and generating dynamo are carried in front, and a small steam dynamo is used for excitation. The main engine is compound, with the cylinders in line, and crankshaft between them. The cranks are set 180deg. apart, so as to obtain balance between the running parts. The cylinders are 16¾in. and 25⅝in. in diameter, the stroke being 12in. The brake horse-power at 300 revolutions per minute is 600, and at 500 revolutions 800 h.p. Weight of engine, 5 tons 3cwt. The generating dynamo is coupled direct to the engine shaft, and is a six-pole machine with ring armature wound for 400 volts and 1,025 amperes, at 300 revolutions per minute. The diameter of the armature is 49in. Each of the eight axles are provided with a four-pole motor of the iron-clad type; diameter of armature, 25½in.; diameter of driving wheels, 45½in. Maximum speed of motors, 560 revolutions per minute."

The electrical equipment of the locomotive is admirable throughout, as might be expected from the firm (Messrs. Brown, Boveri, and Co., Basle, Switzerland) responsible for it, and no criticism of any part thereof is required. So far as the steam plant is concerned, it seems advisable that some improvements should be effected in the main steam-engine. At present the stroke is far too short for the energy transmitted, and serious knocking with heavy wear would result in practice. Steam-turbines cannot well be employed in the absence of condensing plant if a reasonable efficiency is to be aimed at, but an engine of the Willans or Rigg type might serve the purpose, if the height can be kept down.

The arrangement of boiler adopted is good, and, indeed, except for the main steam-engine, the entire locomotive strikes one as being a thoroughly well-designed and sound piece of engineering.

Of course the conditions of a trial trip are no great criterion of working practice, but it was easy to see, when running last week, that in all essential features the locomotive fulfilled the claims put forward by its inventor, whilst several minor details, to which objection could readily be made, were such as might be remedied with little trouble. When accurate figures can be obtained and published as to the coal and water consumed for a given electrical output or haulage effected, it will be possible to compare the Heilmann locomotive with others operated by electricity in the more usual manner, or by steam.

THE CONSTRUCTION AND WORKING OF ELECTRO-MOTORS.*

BY A. H. DYKES, A.I.E.E.

Engineering now embraces so many departments that it is impossible for any one man, much less any young man, to have an intimate acquaintance with them all. The more branches of his profession he possesses a knowledge of, however, the better engineer will he become. It therefore has always appeared to me that one of the chief aims of the papers read before our society should be not so much to describe minutely or discuss exhaustively the latest improvements in any one branch which can well be left to the older societies representing each separate department, but to give members a practical knowledge of the leading features of subjects lying outside their own special line of work. For instance, an advanced treatise on dynamo design, although an excellent paper perhaps for the Institution of Electrical Engineers, might prove of little value to my friend whose work lies among air-compressing machines, and a paper on the very latest improvements in detail of cold-air plant would certainly prove less useful to myself than a more elementary paper on freezing processes. To me, the great charm of our meetings is when some member whose work lies widely apart from my own is kind enough to start me on the right road towards getting a working knowledge of a subject with which hitherto my acquaintance has been slight. So much by way of apology, if any be needed, for venturing to deal with my subject in as simple a manner as possible. If I am able to-night to help anyone to a clearer understanding of the principle underlying the successful application of electromotors, I shall feel that I have to some slight extent repaid the debt of gratitude I owe to the authors of former papers which I have heard at our meetings or read in our *Transactions*.

* Paper read before the Junior Engineering Society.

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We all know that from one pole to the other of any magnet stretch what are called lines of force, invisible to the eye, but capable of showing their presence in various ways, as by the manner in which they cause light iron particles to group themselves in regular lines from pole to pole. Now, if any conducting body through which a current of electricity is passing be placed in this field of force, it will have a tendency to move across the field, cutting the lines of force in its path. If a bar, Fig. 1, is free to roll along the rods, *b b*, in the magnetic field, represented by the arrows, then on sending an electric current through it from the battery, *d*, it will tend to move across the field in a direction at right angles to the current and at right angles to the magnetic field. As long as the friction is greater than the force tending to move the rod, the electrical pressure,

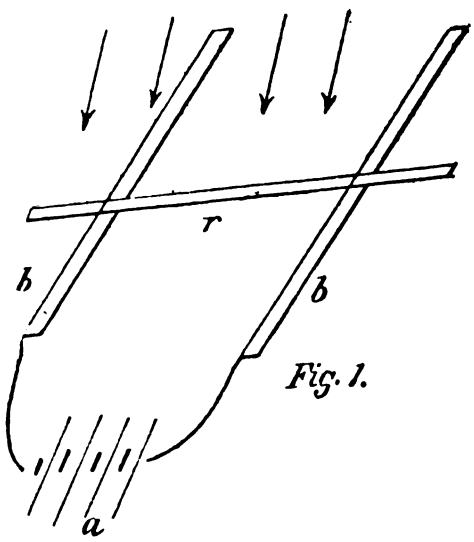

Fig. 1.

or potential, required to drive a given current through the rod will be simply given by the product of the current, *c*, and the electrical resistance, *r*, of the rod—*i.e.*, P.D. $= c\,r$; and the work done $=$ E C, or $c^2 \times r$. When, however, any body cuts lines of force, an E.M.F., or difference of electrical pressure, is set up in it, and therefore directly the electrical force acting on our rod overcomes the friction, and the bar begins to move, the P.D. to drive the current through it $=$ P.D. $= e + c\,r$, where *e* is the E.M.F. set up in the bar due to its cutting the lines. The electrical work done is now $c\,e + c^2\,r$, where $c\,e$ is the equivalent of the mechanical work done in moving the rod against the opposing friction, and $c^2\,r$ the loss in electrical resistance or the internal losses of our elementary motor, and shows itself in heat. From the principle of the conservation of energy, it is clear that if the rod moves against friction or other opposing forces, and thus does mechanical work, we must do work on it, and therefore it is that we get an opposing E.M.F., or back E.M.F., which obliges us to do more electrical work in forcing the current through the bar.

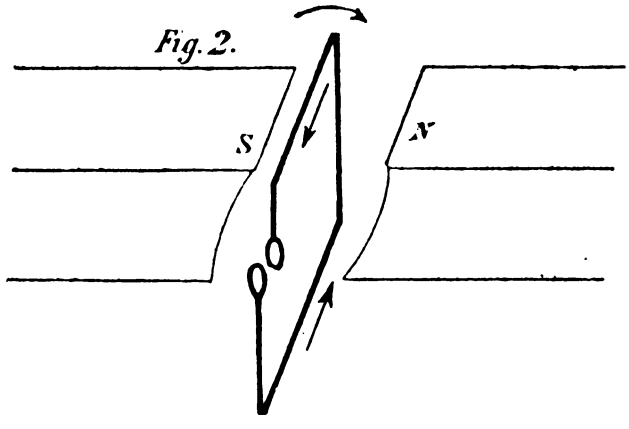

Fig. 2.

All electromotors are simply a combination of these two elements—a magnetic field and a conductor, or conductors, carrying a current. The motion of translation is, however, generally turned into one of rotation, the first step towards which is shown in Fig. 2. Suppose a current be flowing in the direction of the arrow along the top half of the loop, it will try to move it at right angles to the current, and at right angles to the lines of force—*i.e.*, as shown by the curved arrows. The lower half will also tend to move in the same circular direction, and this movement will continue until the coil has moved into the vertical position, when it will stop, this position being a dead point as the motor is at present arranged. If we wind the coil on an iron core, the field will be strengthened, and so the force greatly increased. If, when the coil has made half a revolution, we just help it over the dead centre, and then send the current through it in the opposite direction, it will continue to turn in the field till it completes the revolution. But it can only complete the revolution if the current is reversed after passing the vertical, because in relation to the lines of force each individual half of the coil is moving in the opposite direction during the second half of the revolution to what it was before. We can reverse the current automatically by leading it, not directly to the coil, but by means of brushes to two segments connected one with either end of the coil. This arrangement is called a commutator. The motor, however, will still have a varying torque through the revolution and two dead points. The torque can be made more uniform and the dead centres done away with if we wind a second coil at right angles to the first, so that it is in its best position when the first is on the dead centre, and send the current through both. In practice we put, not two coils only, but many coils, usually 30 at least, and so get a practically uniform torque. The function, then, of the commutator is to reverse the current in the coils as they successively come into the idle parts of the field. There are two principal ways in which moving coils or armatures are wound on the iron core: one by winding right round a drum-shaped core and called a drum armature, and another by winding round a ring, and known as the Gramme winding.

The torque exerted by a motor depends on (*a*) the number of lines of force passing through the armature—*i.e.*, on the strength of the field produced by the field magnets; (*b*) on the current passing through the armature; (*c*) on the number of turns of wire or conductors on the armature. Suppose that a certain armature having a resistance of 0·5 ohm has to give a torque of 100lb.-feet, and that it is so proportioned that it takes 10 amperes to do this. Then, if the volts on the terminals are five, the armature will just give the torque, but will not move P.D. $= c\,r$. If the P.D. on the armature is more than five—say 100 volts—the armature will run faster and faster until the back E.M.F. is 95 volts. Now the E.M.F. set up in any moving conductor is rate of cutting lines, so that if the field be constant the back E.M.F. is speed, and whilst the torque depends on the current, the speed is dependent on the voltage applied to the terminals of the armature, and the horse power of course on the product of the amperes and volts. The torque any motor can give is simply limited by the amount of current that can be sent through the armature. If the motor mentioned above were suddenly called on to give a torque of 1,000lb., it would simply slow up until its back E.M.F. was only 50 volts, thus leaving 50 volts to drive a current of 100 amperes through the resistance of ·5 ohm. If the load on the motor be increased still further, so that it cannot move at all, the current will be $\frac{100}{\cdot 5} = 200$ amperes, or 20 times the normal. The effect of so excessive a current as this would be to overheat the armature winding and probably burn it out.

Where a motor is fitted with a brake for stopping it, it should be arranged that the action of putting on the brake first stops the current. It is also as well to arrange with belt-driving motors that the belt slips if too great a load is put on, and so relieves the motor from an excessive electrical strain. In any case, fuses should be put in the circuit to meet if the current exceeds, say, three times the normal. The magnetic field in which the armature rotates can be produced either by hard steel permanent magnets or by electromagnets of soft iron or steel; the former material is practically used only for very small motors. Electromagnetic fields are excited in several different ways, depending on the conditions under which the motor has to be worked. The two most usual windings being the series and shunt.

In a series-wound motor the current, after passing through the armature, goes round the field magnets—the winding consisting of a comparatively few turns of thick wire. Since the strength of an electromagnet, or the number of lines of force passing through it, varies with the ampere-turns round it, the strength of field in which the armature runs is in a series motor dependent on the current passing through the armature. Now, if the E.M.F. on the terminals of the armature be constant, the weaker the field the faster it must run to generate sufficient back E.M.F. to keep the current down to just that quantity sufficient to do the mechanical work required. It therefore follows that in a constant voltage circuit the speed of a series motor varies inversely as the current taken by the armature. To take an instance. The motors used on the City and South London Railway take normally a current of about 65 amperes, and run at 222 revolutions per minute, 17·8 miles per hour. The pull they then give on drawbar of the train is 447lb. each. When the torque is increased to 1,642, the current is 163, and the speed 125 revolutions per minute. It will be noticed that increasing the current from 65 to 163, increases the pull to 1,121, and the increase in the strength of the field due to the increased ampere-turns brings the total torque up to 1,642. On the other hand, when the current is only 47, the pull is 298 and the speed 230 revolu-

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tions per minute. A series motor, then, possesses the advantage that at starting it is able to exert a large torque because its field is then at its maximum strength, but it is absolutely no use where constant speed under varying load is required. It is extremely well suited for electric tramways and railways where at low speed, when starting a great pull is required, which gets less when the train is well under way. The usual plan is to have in series with the motor a starting resistance, which is cut out at such a rate that the starting current is about two and a half to three times the regular working one. As the inertia of the train is overcome the current drops, and the speed therefore increases until it attains the normal. After this any increase is obtained by weakening the field, either by cutting out some of the series coils or, better, by shunting part of the current round them. The only limit to the speed that can be obtained by these means is when the current in the armature becomes too great, or the sparking owing to the weak field too excessive.

In a shunt motor the field-magnet winding is in parallel with the armature, and consists of a comparatively large number of turns of fine wire, through which only a small fraction of the main current passes. If used on constant-potential leads, the excitation of the magnets is constant, and quite independent of the armature current, and therefore if it were not for the drop in volts due to the resistance of the armature, the speed would be constant; e (the back E.M.F.) $= E - c\,r$, so that if r is appreciable the back E.M.F. is reduced, and therefore the speed decreases with the current. This is, however, somewhat counterbalanced by the increased current in the armature demagnetising the field, and therefore requiring a higher speed to give the same back E.M.F. For all practical purposes, a shunt-wound motor, well designed, and having an armature of not excessive resistance, gives constant speed with constant P.D. on its terminals. Before switching current on to the armature of a shunt motor the field circuit must be closed and the magnets excited, otherwise, the armature offering, when at rest, little resistance, an excessive current will pass through it, and practically move round the fields, and the motor will not start. The shunt switch should be combined with the starting switch, so that the main current cannot be switched on until the magnets are first excited, nor the shunt circuit broken until the armature circuit is disconnected.

With both series and shunt motors, a starting resistance should be put in series with the armature at starting and gradually cut out as the speed, and, therefore, the back E.M.F., increases. The reason for this is, that just when starting, the back E.M.F. is nought, and therefore switching on full volts would send an extremely large current through the armature, causing a sudden jerk on the gearing and on the armature conductors, and also heating the winding. If the motor be running off a lighting circuit, too, such a sudden rush of current would cause the lights on the same mains to flicker. Most supply companies, therefore, stipulate that the resistance is to be such, and divided up into so many steps, that the current shall not at any step be increased by more than 10 amperes. Constant-current motors are little used in England. In America, where constant current as lighting circuits are so popular, they are better known, series motors being often run thus. The speed is regulated or kept constant by cutting out some of the field coils when less torque is required, and putting all of them in series when the maximum pull has to be given. To sum up. Where constant speed with varying load is required, shunt motors on constant-potential circuits (as lighting circuits) should be used; but where the work is constant, or where a large torque at starting, diminishing as the speed increases, is wanted, series-wound motors are most suitable. We therefore find shunt motors driving workshops, machines, etc., and series motors on electric locomotives, trams, and boats, and also driving fans and centrifugal machines. For electric drills series motors have also been used, as they automatically slow down when taking a heavy cut with a large drill, and speed up when drilling a smaller hole. Other things being equal, a series motor is cheaper to make than a shunt, as the field coil, being only comparatively a few turns of wire, takes less time to wind than a shunt coil consisting of a large number of turns of fine wire.

The efficiency of a moter of given size depends on the speed at which it runs—the higher the speed the greater the efficiency. For example, take the case of a motor giving 10 brake horse-power at 500 revolutions, and absorbing 100 volts and 88 amperes; 10 h.p. is equivalent to 7,460 watts, whilst the watts absorbed are $88 \times 100 = 8{,}800$, leaving 1,340 watts wasted in heat inside the motor itself, or an efficiency of 84·8 per cent. If we supply it with current at 200 volts, so that it runs at just over double the speed, the power wasted inside will remain the same, and the output will be $(200 \times 88 = 17{,}600) - 1{,}340 = 16{,}260$, giving an efficiency of $\frac{16{,}260}{17{,}600} = 92{\cdot}4$ per cent.

High-voltage motors are usually much less efficient than those wound for lower pressure, as there is a great deal of space taken up by insulation which gives less room for copper. A large 300-h.p. motor wound for 250 volts, at a speed of 350 revolutions, had a commercial efficiency—*i.e.*, $\frac{\text{mechanical power given out}}{\text{electrical power absorbed}}$, of 96 per cent. The City and South London Railway motors gave an efficiency of 94 per cent. at 222 revolutions. A 220-volt motor giving 3½ brake horse-power at 394 revolutions gave 70 per cent., whilst at 1,600 revolutions a 1½-h.p. 100-volt motor gave 75 per cent. When specifying the efficiency of a motor, then, these considerations must be taken into account, as what may be a low efficiency under one set of conditions may be a high one under another. First, the higher the speed the greater the efficiency; secondly, the higher the output the higher the efficiency; thirdly, usually the lower the volts the higher the efficiency.

We have seen above that the function of the commutator is to reverse the direction of the current in each armature bar or winding, as it gets into the neutral part of the field. When the motor is running light, and scarcely any current passing through the armature, the main field runs straight across from pole to pole. The effect of the currents circulating round the armature is to magnetise it in a direction at right angles to the main field, the magnetisation increasing with the current. This causes a resultant field inclined to the main field, and necessitates the line of the brushes (which has to be approximately at right angles to the field) being shifted backwards, or, as it is called, "having a back lead," by an amount increasing with the current. (If the brushes are not shifted backwards excessive sparking will result, causing great wear of the brushes and commutator.) Obviously this lead can be made very small by making the main field very powerful comparing with that due to the armature. In tramway motors and others that have to be put into inaccessible places, where the brushes cannot be shifted as the load varies, it is of the utmost importance that the armature field be very weak.

When selecting a motor to do certain work, the torque, or effort, it has to give at starting should be borne in mind, as well as simply the horse-power it must give when running; and if it is to be started and stopped very often, it pays well to put in an amply large motor. It is, unfortunately, only too easy to put a sudden excessive strain on the armature when starting by switching out the starting resistance too suddenly. Many pieces of apparatus, such as centrifugal machines, take a very large torque to start them, but little power to keep them running when once they have been started. All motors should have at least two brushes on each side of the commutator, or four in all, so that in the event of one pair being disabled, the current can still flow through the other. Great care must be taken to keep all parts of the machine clean, especially the commutator. Oil and dirt on the latter is responsible for many a failure. No part of the magnets or armature should be allowed to get too hot, a temperature of 200deg. F. being about the limit for safe continuous working. For short runs, the normal output of the motor can be considerably exceeded, provided that at no time does the temperature rise higher than the figure given, and that the commutator be not injured by sparking.

The faults most likely to occur are two—"earths" and "shorts," the former being when any part of the winding or commutator makes contact with the frame or earth, and the latter, when two parts of the winding, supposed to be insulated from each other, come into contact. The final result in both cases is usually the same—an excessive local current flows and burns out the injured part. The "earth" can be detected by connecting either terminal of the machine in turn to one end of a piece of wire and striking the other end of the wire on to the spindle or frame. If there is any earth there will be a flash or spark when the wire touches the frame. A "short" can be found by running the armature in its fully excited field and holding near to it a key or other light piece of iron. If the winding is sound a steady pull will be felt on the key, but in the event of a "short" there will be a jerk or tug on the key whenever the bad place on the armature comes opposite it. If run long enough the fault will also show itself by local heating of the damaged coils. It also often happens that the wires connecting the commutator parts with the winding break, a fault to which tramway motors which run in both directions and have to endure a lot of vibration are particularly liable. If, however, care be taken to handle the armatures gently, to prevent the insulation getting scratched or knocked, and to keep the whole machine clean and dry, motors give very little trouble, and require no skilled attendance. They are safe, clean, and noiseless, and can be started and stopped with the utmost ease, and thus can be put into a situation where any other form of motive power would be out of the question.

The Electro-Harmonic Society.—A ladies' night of this society will take place in the Banquet-room of the St James's Hall Restaurant, Regent-street, W., on Friday next, the 23rd inst, commencing at 8 o'clock. The programme, although short, should prove interesting. The artistes include Miss Beatrice S. Lucas, Miss Rose Dafforne, Mr. T. H. Harrison, and Mr. Holroyd Smith. The musical directors are Messrs. T. E. Gatehouse and A. E. Izard.

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ST. PANCRAS ELECTRIC LIGHTING INSTALLATION.*

BY PROF. HENRY ROBINSON, M.I.C.E., M I.E.E.

I have pleasure in complying with the request that I should describe at the Society of Arts the electric light installation that I have carried out for the St. Pancras Vestry. I would state at the outset that St. Pancras was the first municipal authority to appreciate the importance of preserving the business of electricity supply in its own hands, inasmuch as in the year 1882 the vestry clerk, Mr. T. Eccleston Gibb (to whom is mainly due the successful action of the Vestry throughout), called the attention of the Vestry to schemes which had for their object the acquisition of electric lighting powers in the St. Pancras parish. In a report of his in that year he says: "A few years ago it was generally believed that electric lighting would not be made available for private houses and buildings for many years, although it might shortly be brought into use for public lighting. The invention of the incandescent lamp and other improvements have revolutionised the question of electric lighting, and while public authorities are in many cases giving up their experiments in street-lighting, the several companies are extending their systems to buildings of all descriptions, and the time seems to have gone by when there is a willingness to undertake costly experiments in public lighting. It is probable now that the electric lighting will be adopted in private buildings before the local authorities adopt its use for street-lighting, and, therefore, the acquisition of the powers of monopolists are more likely to pass unnoticed by the local authorities, and thus control over streets, etc., obtained similar to that exercised by water companies."

In connection with the views thus expressed by Mr. Gibb, as far back as 1882, I would quote the following from the inaugural address of the President of the Institution of Electrical Engineers in January last: "The financial success which has invariably attended the municipal electric enterprises has relieved the rates at the expense of the wealthier classes in a perfectly legitimate manner; and the more electricity becomes one of the common necessaries of life, the better it is that the supply should be in the hands of the community, and not in those of monopolists. A strange fact in connection with this subject is that the great majority of the local authorities should have waited until the passing of the Electric Lighting Act, 1889, before applying for powers to supply electricity, for it must not be forgotten that their position was in no way affected by the alteration of the Electric Lighting Act, 1882. The explanation must, perhaps, be looked for in the exaggerated expectations that were raised by the statements of company promoters in the year 1882, when the most reckless assertions were made as to the results to be obtained by establishing electric systems of distribution The natural consequence was that the enquiries set on foot by various local authorities in no way confirmed the sanguine estimates that had been dangled before the public to obtain its support; and the total failure of the electric light companies to carry out a single one of the orders and licenses obtained by them in the year 1883 and 1884, made the local authorities hesitate before they embarked the ratepayers' money in such precarious undertakings. Fortunately for the progress of our industry, there were some corporations who could be convinced by the result of their enquiries that the use of electric light would be very advantageous for a variety of purposes, and that the knowledge and ability of the electrical engineers had progressed sufficiently to make a profitable distribution of electricity from a generating centre possible. We have seen that their example has been largely followed, and there is every prospect of a continuous and ever-increasing development of this branch of electrical engineering."

On the passing of the Electric Lighting Act, 1882, I, in conjunction with Dr. Hopkinson, F.R.S., advised the Vestry to obtain a provisional order, and it was obtained in 1883. Owing chiefly to financial and other difficulties in connection with the electric lighting companies, as before mentioned, public confidence was shaken, and the order remained in abeyance. In 1888 various companies made applications for provisional orders, by which the Metropolis was proposed to be divided amongst them, but at the Board of Trade enquiry that was held in 1889 the St. Pancras Vestry succeeded in getting their district excluded from the operation of any company. I was thereupon instructed to prepare a scheme to serve in the first instance the south-west, or Regent's Park, division of the district, which formed the compulsory area under the order. In advising upon this, I kept in view the ultimate requirements of the other parts of the St. Pancras district, so that the first installation should form part of a comprehensive scheme. I decided upon adopting the continuous-current system.†

The situation of the site that was originally proposed by the Vestry necessitated the employment of high tension with five transformer sub-stations to feed a network of low-tension distributing mains. The ultimate acquisition by the Vestry of a more central site in Stanhope-street (consisting of 21,000 square feet of freehold property, purchased for £10,000) enabled me to adopt the low-tension direct-supply system entirely for private lighting, and to have only one battery sub-station at the Cobden Statue, 1,140 yards from the central station. It was decided to work the public arc lamps by high-tension continuous current independently of the private lamps. The plant was designed at the outset to serve 10,000 incandescent lamps of 16 c.p. simultaneously in use, and 90 arc lamps of 10 amperes each for public lighting. I should mention that the action taken by the Vestry was not adopted without strong opposition being offered (which is, in fact, still continued) to the Vestry's undertaking this work. However, on January 1, 1890, authority was given by a large majority for the work to proceed. Having overcome opposition from within, a quite unexpected difficulty arose in consequence of uninvited advice and proposals being made from outside (not altogether of a disinterested character) which disturbed the minds of the Vestry. On my advice Dr. Hopkinson and Mr. Preece were consulted, and it was a satisfaction to me that they entirely concurred in my proposals, and the execution of the works, which had thus been interrupted, was proceeded with.

The following is a description of the works: The buildings consist of an engine-house 106ft. by 26ft., a boiler-house 53ft. by 35ft., coal-store 43ft. by 11ft., battery-room 40ft. by 14ft. 6in., testing-room, office, stores, underground tank for condenser water containing 170,000 gallons, chimney 5ft. square inside and 90ft. high. There are 11 engines and dynamos, which are erected on a concrete foundation surrounded by sand to prevent vibration being communicated to the walls, and the floor is carried, independently of the engine foundation, by cantilevers from the walls. The engines are of the Willans type, and the dynamos are of the six-pole Kapp type (made by Messrs. Johnson and Phillips). Nine of these are wound for an output of 680 amperes at pressure varying from 112 to 130 volts. Three are capable of giving 145 volts with a small current for charging batteries at the sub-station, and can be worked self-exciting as simple shunt machines, or separately excited. They were tested with a load of 680 amperes at 118 volts, and the steam consumption was found to be 18·65lb. per electrical horse-power per hour, working condensing, and with the dynamo separately excited. The remaining two dynamos are wound for an output of 90 amperes at from 540 to 575 volts. They are separately excited at low tension, and are used for working 86 arc lamps in the streets, as well as for charging in series four sets of storage batteries of 60 cells each at the central station, which are capable of discharging 60 to 75 amperes. The trials of these two engines showed a consumption of 19·6lb. of steam per electrical horse-power per hour. There are five Babcock and Wilcox boilers, each being 23ft. long and 5ft. wide between the walls, with one steam-drum 3ft. 6in. in diameter. Each boiler has a heating surface of 1,619 square feet and a grate area of 30 square feet, and is capable of evaporating over 5,000lb. of water per hour, the working pressure being 170lb. per square inch. There are two 6in. steam-mains along the top of the boilers fed by separate outlets from each boiler, and delivering into a 6in. main (which extends the whole length of the engine-house) at three points. The mains are so arranged that only two engines are put out of use by the removal of any one pipe. The long pipes are made of wrought iron, the short pipes and T-pieces of cast iron, and the bends of copper. The main exhaust-pipe, under the engine-house floor, varies from 5in. to 15in. in diameter. The steam can be exhausted to the atmosphere, but under ordinary circumstances it passes into a jet condenser, which draws its water from the bottom of the underground tank. Two air-pumps, driven by a Willans compound engine, discharge the hot water from the condenser into the top of the tank. A Körting ejector condenser is provided as a stand-by for heavy loads. From the top of the tank the hot water is pumped by independent circulating pumps to a cooling apparatus, which is capable of dealing with a minimum of 10,000 gallons per hour. The cooling arrangements consist of a large surface of corrugated iron sheets, attached to framing placed round the chimney shaft, the water, after flowing over the corrugated surface, being collected beneath and returned to the bottom of the tank. A dry-air machine is provided for the purpose of delivering dry air into the street-main culverts at the rate of 5,000 cubic feet of air per hour. The air has its due point lowered to 40deg. F.

The arc lamp-posts (86 in number, displacing 479 gas lamps) are of the Brockie-Pell type, and are placed in the centre of the road where this is admissible. In some places, however, they had to be placed on the pavements, as tramways prevented them from being in the middle of the roads. The first lamps that were erected (in Tottenham Court-road and Euston-road) are 25ft. from the ground to the centre of the globe, but those more recently put up, which are chiefly on the pavements, are 22ft. They are fixed at distances varying from 160ft. to 245ft. apart, and are fed with a current of 10 amperes. Eleven lamps are worked in series near the central station, and 10 in series at a distance. Nine arc lamps have more recently been put up in Park-street and supplied with current off the low-tension mains. The main switchboard is arranged on the three-wire system. Each dynamo is provided with a double-pole switch and copper coupling straps to connect the machine to the third wire and to different bars on the feeder-board on either side of the circuit. There is an amperemeter on each dynamo. One terminal of the dynamo switch is coupled by a strap to the third-wire main, and the other terminal is coupled to a bar on the feeder-board. There are four positive bars and four negative bars, and at full load one machine can be run on to each bar and worked at any pressure which may be necessary to serve the feeders which are switched on to it. Thus the dynamos may all be worked at different pressures to suit the demand in the districts which they serve. There are seven feeders, in addition to a direct supply on to the distributing mains, which are connected in a network throughout the district. The bars on the board may be connected directly in parallel or through resistance cells, which will each carry currents up to 180 amperes, offering a counter E.M.F. of from 2 to 2½ volts. By using these cells, current can be supplied to the feeders at four or five different

* Paper read before the Society of Arts on February 14.

† Some data in regard to the various systems of distributing electrical energy I have recently had printed in pamphlet form, and they can be obtained of Messrs. Spon.

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pressures from one dynamo, which enables the dynamos connected to long feeders to help those serving short feeders, and further enables regulation over large areas when only one dynamo is at work on each side of the circuit. There is an underground sub-station beneath the open space at the Cobden Statue, High-street, Camden Town, at a distance of 1,140 yards from the central station which contains two batteries of 58 cells each. The mains are laid throughout on the "three-wire system," the arterial mains being sufficient to supply 25,000 lamps of 16 c.p. in use simultaneously. The conductors are chiefly composed of bare copper strip 1¼in. wide and ⅛in. thick, supported on edge in glazed porcelain insulators, which are carried on small cast-iron brackets built into the walls of the culverts. Some of the mains are cables laid in cast-iron pipes, and in the extensions now being carried out they are Siemens armoured cables.

The works originally authorised I estimated would cost about £50,000, and this estimate was increased to about £52,000 when the Stanhope-street site was adopted. The actual cost of the works when completed was about £56,000, or within 8 per cent. of the estimate, which, I think it will be admitted, was satisfactory. During the execution of the works originally authorised by the Vestry, extensions were made by the Vestry which involved a considerable increase in the capital expenditure. The works were so far completed as to enable public supply to be commenced on November 9, 1891 (or a year after laying the first stone). By the end of January, 1892, there were 6,500 incandescent lamps of 16 c.p. installed (or their equivalent), and at the end of 1892 there were 11,733, and at the end of 1893 there were 14,617 lamps installed, and many more contracted for, to come on shortly. The current for ordinary supply is charged at 6d. per unit, but it is charged at only 3d. per unit for what is termed "day load," but what might be defined as current supplied for motive power and other purposes at times other than those of maximum demand. The public lighting is at present charged for at the rate of 6d. per unit, which covers the entire cost of production as well as for carbons, trimming, etc., together with all capital charges and maintenance, including lamp columns, lamps, street refuges, etc. The electricity department takes charge of all these matters, and the public lighting account is only debited with one item, "current used," at 6d. per unit. The cost of carbons and trimming for the 95 public arc lights in 1893 was about £600.

CAPITAL EXPENDITURE TO DEC. 31, 1892.

	£	s.	d.
Lands (part only utilised)	10,827	0	0
Buildings	7,653	17	1
Machinery and plant	24,378	17	8
Batteries at central station and sub-station at Cobden Statue	2,961	6	11
Mains, of which some are capable of carrying current for 25,000 lamps	33,787	15	3
Public lamps	6,723	8	4
Meters	1,556	3	9
Electrical instruments, etc.	284	16	3
Office and other furniture and fittings	186	7	4
Preliminary expenses	554	4	7
Total expenditure to December 31, 1892	£88,913	17	2

During the year 1893 a sum of about £10,000 was expended in extensions of lighting, together with mains, meters, house connections, etc. A further increase of the generating plant at the central station has been rendered necessary, owing to the increasing demand for current. These works are now nearly completed, and consist of an extension of the central-station buildings to receive three more engines and dynamos, three additional boilers, together with a second sub-station in Fitzroy-road, near Primrose Hill, 2,700 yards from the central station, containing two sets of batteries. These extensions will cost about £13,000. The "fixed charges" in the shape of the permanent staff, etc., commenced in the middle of 1891, before the public supply of current began. Some of the working expenses of the station during that year, and also in 1892, were incidental to a new undertaking. The following figures for those years, therefore, do not admit of being taken as any criterion of what the normal relation between receipts and expenses will be, but they are given as a matter of record. From the commencement of public supply in November, 1891, to December 31, 1892, there were 11,733 lamps of 16 c.p., or their equivalent current, installed (including 11 motors = 36 h.p., and 92 private arc lamps), of which 6,823 were in simultaneous use. The number of units sold to the end of 1892 was 433,519. The amount charged for lighting the 86 public arc lamps (which were at work only part of the year) was £2,040, the current being charged at 6d. per unit. The total working expenses of all kinds from the commencement to the end of 1892 were £7,438. A sum of £408 was expended on the maintenance of plant. A capital sum of £4,119 was repaid, made up of £400 capital and £3,719 for interest on loans at 3½ per cent. The number of tons of coal used to the end of 1892 was 2,728, and its cost was £2,828, the price of coal being from 20s. to 21s. 6d. per ton. For the year 1893 the following are the figures:

Number of 16-c.p. lamps installed, or equivalent current, including 19 motors = 61 h.p. and 110 private arcs	14,617
Number of 16-c.p. lamps, or equivalent current, simultaneously in use	6,187
Number of units sold for private lighting	397,217
Number of units sold for public lighting	197 676
Total number of units sold	594,893
Receipts for private lighting	£9,546
Receipts for 93 public arc lamps, the current being charged at 6d. per unit	£4,941
Total receipts for current	£14,487
Working expenses	£7,033
Repayment of capital £1,628; Interest on capital, at 3½ per cent. £2,797	£4,425
Expended on maintenance	£1,402
Total for working expenses, repayment of capital, and maintenance	£12,860
Number of tons of coal used	3,180
Cost of coal (price about 17s. 9d. per ton)	£3,006
Cost of coal per unit sold*	1·21d.
Cost of a unit sold if capital had not been repaid	3·4d.
Cost of a unit sold with capital repaid, and maintenance	5·18d.

* This was more than it should have been.

The following table may be of interest:

TABLE GIVING A RECORD OF THE VARIATIONS OF LOAD DURING THE YEAR, AS TAKEN FROM THE LOG AT THE STATION.

Maximum loads observed at Regent's Park station, 1893.			Maximum loads observed during December, 1893.			
Date.	Amperes.	Time.	Date.	Maxim'm amperes.	Time.	Maximum load.
Jan. 3	1,570	4.15 p.m.	Dec.		P.M.	P.M.
	3,670	6.15 ,,	1	2,950	7.45	4.30 to 8.0
	1,140	9.15 ,,	2	2,455	7.45	4.30 ,, 10.0
	1,295	5.0 ,,	3	755	7.15	6.0 ,, 10.0
Feb. 28	2,140	7.30 ,,	4	2,310	7.45	4.30 ,, 8.15
	1,010	9.45 ,,	5	2,320	7.45	4.30 ,, 9.0
	900	6.45 ,,	6	2,380	7.45	4.30 ,, 9.0
March 28	2,210	7.45 ,,	7	1,970	7.45	4.30 ,, 8.15
	1,065	10.15 ,,	8	2,455	7.45	4.30 ,, 8.30
	730	7.15 ,,	9	2,555	7.45	4.30 ,, 10.15
April 24	2,305	8.0 ,,	10	785	8.15	6.0 ,, 10.0
	930	10.45 ,,	11	2,540	5.45	4.30 ,, 8.0
	1,090	7.45 ,,	12	2,560	5.45	4.30 ,, 8.15
May 13	2,180	8.45 ,,	13	2,870	7.45	4.30 ,, 8.30
	1,225	11.15 ,,	14	2,190	7.45	4.0 ,, 8.30
	835	8.15 ,,	15	2,560	5·15	4.0 ,, 8.30
June 24	2,010	9.15 ,,	16	2,610	7.45	4.30 ,, 10.15
	1,085	11.15 ,,	17	795	6.15	4.0 ,, 8.30
	1,740	8.15 ,,	18	2,995	7.45	6.0 ,, 10.0
July 29	2,045	8.45 ,,	19	2,765	7.15	4.30 ,, 8.30
	1,180	11.15 ,,	20	2,675	7.45	4.30 ,, 8.30
	865	7.15 ,,	21	2,815	8.15	4.30 ,, 9.30
Aug. 22	2,140	8.0 ,,	22	2,885	8.15	4.30 ,, 10.0
	785	11.15 ,,	23	2,800	7.45	4.30 ,, 10.0
	830	6 30 ,,	24	790	9.45	6.0 ,, 10.0
Sept. 15	2,555	7.45 ,,	25	715	6.45	6.0 ,, 10.0
	805	11.15 ,,	26	1,065	7.15	4.0 ,, 10.0
	2,355	5.15 ,,	27	2,335	7.15	4.30 ,, 9.0
Oct. 30	2,695	7.30 ,,	28	1,905	7·45	4.0 ,, 9.0
	1,050	10.15 ,,	29	2,745	7.45	4 30 ,, 8.0
	1,180	4.15 ,,	30	2,645	7.45	4.15 ,, 10.0
Nov. 29	2,695	7.45 ,,	31	775	6·45	6.0 ,, 10.0
	1,070	10.45 ,,				

The year 1893 was exceptionally free from fogs, and those which occurred were, I believe, chiefly on Sundays. This led to the receipts for current per lamp installed for that year being below what may be expected over an average number of years. In considering the foregoing table, it should be remembered that the capital repaid is in respect of the cost of a site, the cost of mains, permanent charges, etc., for the supply of a far greater number of lights than those which were supplied during the year, so that, in future years, the cost of production will diminish, inasmuch as the fixed charges and repayment of capital will be spread over a much larger output.

The question of the terms of repayment of the capital for electric lighting by municipal authorities is now receiving serious consideration, as affecting the price at which the public can be supplied with current. The matter has been dealt with by Mr. Gibb, and I refer to the views that he has lately brought before the London County Council, as I am of opinion they have an important bearing on the municipalisation of electric lighting. It has been sought to make the period for repayment of the loans dependent on the life of the machine or apparatus to which it applies, instead of for 42 years. A limit of 42 years was adopted by Parliament, instead of 21 years fixed upon in 1882, as it was found that the shorter period did not enable companies to recoup themselves for their outlay on the monopoly granted them. As it now stands, the ratepayers can only acquire the electric lighting undertakings of companies at the end of 42 years by purchase at their then value; whereas, if an authority extinguishes its capital in 42 years, the future ratepayers succeed to the undertaking without any payment whatever. The view the St. Pancras Vestry take is that the repayment of capital should be spread over a period of 42 years, and that renewals should be met out of profits, supplemented, if need be, by a rate or loan, when the extent of the expenditure justifies it being spread over several rates, by which the present generation of ratepayers would be able to have the benefit of cheap electricity, which it could not otherwise have.

It is often stated that the cost of public lighting by electricity is greater than by gas. If the same standard of illumination had to be obtained by gas as by electricity the statement would not hold good. It is entirely a question of whether or no the standard of lighting does not require to be raised. I think it does. The present lighting of the thoroughfares in the Metropolis is a

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reproach, and St. Pancras has led the way in reforming this. I am confident that at no distant date the present inefficient lighting of the streets will be looked back upon as comparable with the old oil lamps for which gas was substituted at a great increase in the cost of public lighting. Electricity economically produced by an authority will be available for the "masses," and not only for the "classes," as is often thought. Those who live in small rooms will be benefited, as well as those who live in large, as purity of air and freedom from dirt will result in better health, less work in cleaning, and no injury to decorations. The convenience arising from the employment of electrical energy for working motors is being more and more appreciated, and its uses are gradually extending. A leading London paper is now advertised as being printed by electricity. Where economical power is available, it opens out a wide field for encouraging the establishment of industries where small motors are required to be worked intermittently.

From a social as well as from an economic point of view a municipal authority may regard this part of the electric lighting business as another justification for their undertaking it, especially where large populations are concentrated on a limited area. Simple labour-saving appliances which involve no difficulties in working, and which do not lead to the vitiation of the air, are certain to be more and more relied on as a means of enabling some industries to be carried on in the houses of the workers instead of at factories where the motive power is concentrated. The destruction of town refuse is now recognised as about the best way of getting rid of it, both from a sanitary and financial point of view. The heat produced by the combustion of the refuse can be advantageously utilised for various purposes, amongst others for generating steam. This has led to the combination of a refuse destructor and electric lighting station where the heat produced during the time of working the destructors can be applied to do the work of light loads or in aid of steam boilers. I am now, in conjunction with Mr. William N. Blair, the engineer of the St. Pancras Vestry, carrying out a combined destructor and electric lighting station at King's-road to serve other parts of the district, the outlay on which will be about £40,000 without distributing mains, which will connect it with the existing network, and will enable the heat produced during the daytime to be utilised to do the work of charging the batteries and the light load over the whole district.

Having described the satisfactory results that have already been accomplished, I am confident that it only requires ordinary good administration for a still further degree of success to be attained, which will enable the Vestry either to lower its rate of charge below 6d. per unit, or to have a handsome amount each year to devote to the benefit of the ratepayers. I desire to record my thanks to the members of my staff, and especially to my chief assistant, Mr. Thrupp, for their aid in carrying out these works. In conclusion, I think the St. Pancras Vestry may be congratulated on the success that has attended their enterprise, which has fairly realised the anticipations and calculations upon which it was promoted.

THE RECENT ACCIDENT AT BOURNEMOUTH.

BOARD OF TRADE REPORT.

The following report has been presented to the Board of Trade by Major P. Cardew:

I have the honour to report, for the information of the Board of Trade, that in compliance with the instructions contained in your minute of the 8th inst., I have investigated the circumstances connected with the sudden death of a horse at Bournemouth, under conditions which suggested that the cause of death was an electric shock, due to some defect in the mains of the electric lighting company. The following account of what took place I have collected from the narratives of eye-witnesses:

Between 2.30 and 3 p.m., on the afternoon of the 8th inst., a station omnibus drew up in the roadway opposite to the entrance to the Imperial Hotel in Meyrick-road, Bournemouth. As the horses drew up both suddenly fell down. The driver, William Dean, states that he is certain that the horses did not slip, although there was some melting ice and snow on the road at the time. The driver got down to attend to the horses, and he was assisted by the following men: John King, flydriver; W. Brown, flydriver; T. Binden, carpenter. All these men as well as the driver state positively that when they touched the horses they experienced tingling sensations in their arms and legs, which they attributed to slight electric shock. None of them, however, appear to have been injured by the shock, but the driver's foot was hurt by one of the horses treading on it. One horse was extricated and set on his legs, which appeared to be partially paralysed at the time; the other could not rise and died in a few minutes.

On arrival at the spot about noon on the following day, accompanied by the borough engineer and the superintending engineer of the Bournemouth and District Electric Supply Company, Limited, I had the ground opened at the place where the horses fell, and the iron cover of a street box, measuring 2ft. 6in. by 1ft. 6in., was disclosed about 9in. beneath the surface of the road. On lifting this cover it was found to rest on a brick chamber about 1ft. deep, to one end of which was connected a 3in. iron pipe and to one side a 1½in. iron pipe. The larger iron pipe contained two insulated cables, technically described as 7/20 tinned copper wires insulated with high-quality vulcanised rubber to $\frac{1}{16}$in. thickness and protected by braided hemp. The ends of these cables projected to about the centre of the box, and were sealed up with indiarubber tape and composition. Near these ends two smaller cables of 7/21 tinned copper wires, insulated with similar material, but only to barely $\frac{1}{20}$in. in thickness, and with braided hemp outside, were joined to the larger ones and passed into the smaller pipe. The larger cables had been connected to the supply mains through fuses, contained in a large subterranean chamber at the crossing of main roads, known as the "Lansdowne," about 70 yards away. This connection had, however, before my visit, been severed by cutting the cables in the chamber. The smaller cables merely completed the connection to the transformers placed in the area of the hotel, and were 34ft. in length, and the enclosing pipe was laid at a depth of about 18in. below the surface throughout. All the cables mentioned were used for the high-pressure supply of 2,000 volts. There were no signs of any arcing or injury to the cables or to the lid of the street box, the under surface of which was 5½in. above the cables, but I noticed that one of the "dead ends" beyond the joint to the small cable was covered on the outside with a slimy moisture, and I had this end cut off for further test. On testing it subsequently in water with 2,000 volts alternating pressure, however, no fault was developed.

In order to thoroughly examine the cables and the street box, it was necessary to move the former slightly, but they were disturbed as little as possible, and a test was then made of the insulation of both larger and smaller cables together, up to the point where the connection to the mains had been severed at the large chamber. This test, made with about 100 volts from a small hand-machine, gave an insulation resistance of between four and five megohms from the small pipe—a result which did not indicate any serious leak, considering that the cut ends of the cables had not been sealed up, and some leakage from them was to be expected. On consideration of the matter, however, it occurred to me that possibly the slight movement to which the cables had been subjected had sufficed to move a small defect in the insulation away from contact with the pipe, or that the fault might be such as to give high insulation with 100 volts, but to break down when the pressure was increased to 2,000 volts, so that the fault would not be discovered by the electric test I had made. I therefore requested the electric light company to send for my examination the whole of the cables mentioned so soon as they had withdrawn them from the pipes. This was done, and a distinct defect of insulation was discovered in one of the smaller cables, with evident signs of sparking and some burning of the insulating material having taken place. I do not think, however, from the appearances, that the whole leakage current could have much exceeded one ampere.

Judging from the results of my investigation, and from the attached copy of the report of the borough veterinary surgeon of the post-mortem examination made on the horse, I have no doubt that the latter did receive an electric shock, and that probably this shock was the determining cause of death, but that, nevertheless, the shock could not have been a very severe one, and I am inclined to attach much weight to the veterinary surgeon's expression of opinion that the dilatation of the heart may have been a predisposing cause of death. In order to further elucidate the above, I attach a rough tracing of the locality in which I have marked the street box *a*, the small pipe *b*, and the larger pipe *c*.

My explanation of the occurrence is as follows: In the first place, the soil at Bournemouth is of such a nature that it is very difficult to get what is technically known as "good earth." There are alternate layers of sand and clay, and either of these may, under certain conditions, oppose great resistance to the passage of electricity. The soil in which the street box, *a*, and the pipe, *b*, were placed was a peaty sand, but probably a layer of clay exists at no great distance below. Secondly, the accident happened during the progress of a thaw after a very severe frost. Now, water in the solid form is not nearly so good a conductor as it is when liquid, and the juxtaposition of masses of thawed and masses of frozen ground may have greatly influenced the direction and amount of current flow. It is just possible that the small amount of heat produced by the current in the wires contained in the pipe may have determined a more complete thawing of the ground directly above the pipe than in other parts. Thirdly, the pipe which appears to have been directly charged from the cable was only 34ft. long and 1½in. in external diameter, and was not metallically connected to the larger pipe, but terminated at the brickwork of the street box. Even in soil of a highly-conducting nature it would, I consider, be possible to appreciably charge such a short length of pipe by contact with a high-pressure electric wire. Owing to the special conditions above referred to, the potential of the surface of the ground immediately above the pipe appears to have been appreciably affected, and the horse seems to have placed its hind feet upon this charged surface. At the same time one fore foot would be 4ft. or 5ft. distant, and very probably in contact with more freely conducting soil. A current from the charged to the uncharged, or at any rate less highly-charged ground, therefore, passed through the body of the horse.

That any such result as the death of a horse should have followed from so indirect and limited an application of electricity is indeed an extraordinary occurrence, but while the field of enquiry it opens to view must be carefully studied, and any additional precautions which may after due consideration be thought necessary firmly insisted upon by the Board of Trade, I do not think there was any appreciable danger to human life in this case. Experience in many countries has shown that horses are peculiarly susceptible to electric shock, and a horse neces-

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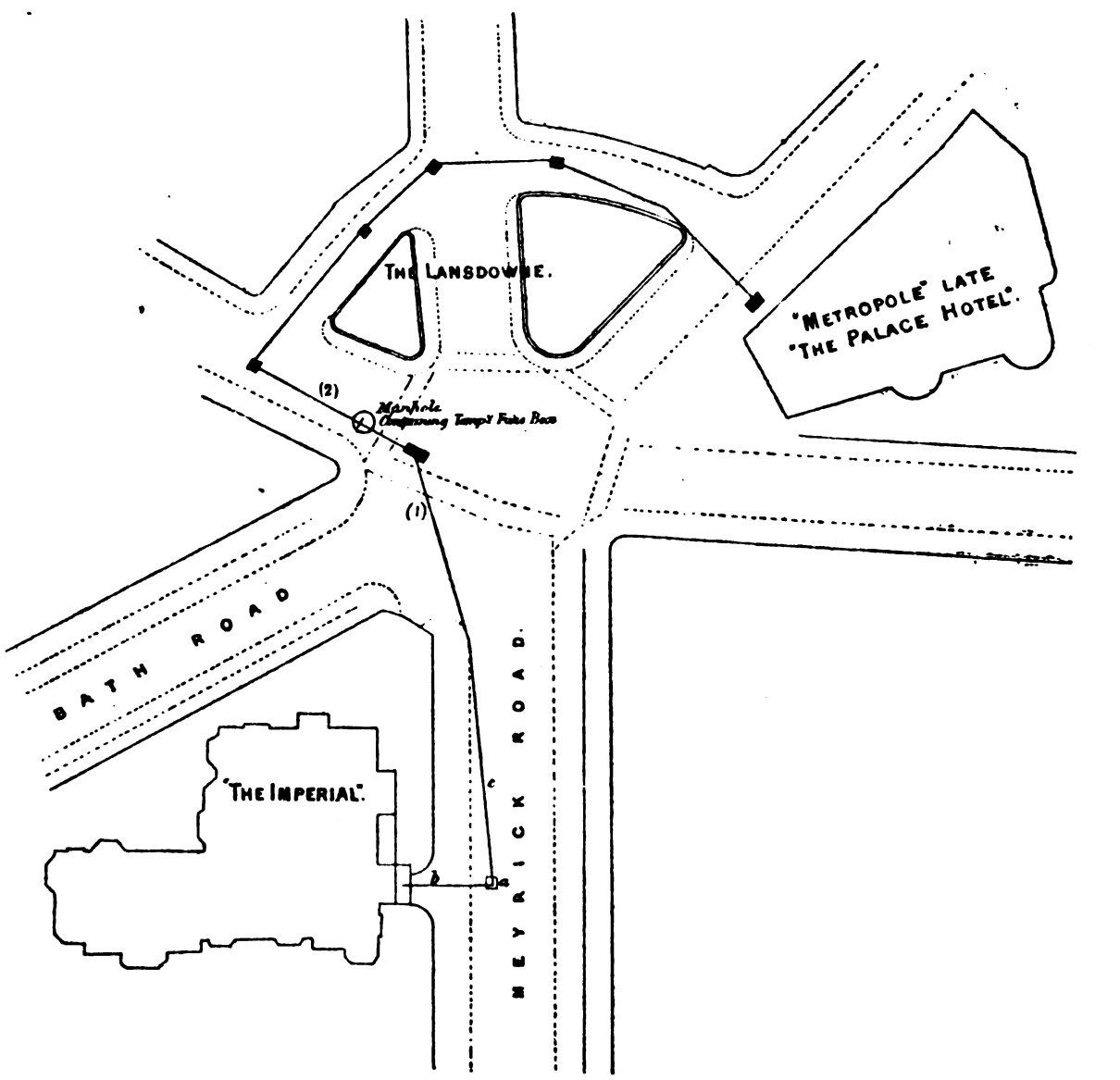
sarily, even when at rest, is in contact with the earth at points much further apart than are simultaneously touched by men, while the iron shoes of the former and its greater weight ensure a more perfect contact where it does touch. These differences are well brought out by the testimony of the men who extricated the horses. When they touched the bridles they felt a shock, because their feet were resting on the ground about 7ft. away from the hind feet of the horses; but no one of them appears to have been conscious of any shock at all except from contact with the horses. The suggestion that people inside the omnibus might have been injured by an electric shock is quite untenable. It is, of course, needless to point out, however, that many people's lives may be jeopardised from the result of an electric shock given to a horse, and that on this account alone it is essential that all danger of such an occurrence should be avoided.

I cannot acquit the electric lighting company of blame in the matter. They had warning by their own tests that a defect of insulation existed on this circuit, but they had taken no steps to localise and remove it, although the insulation of the circuit was considerably below one megohm. Also on the very day of the accident, as will be seen from the attached copy of a report from one of the foremen in the employ of the Corporation, they had received a warning of the state of things, which they should at once have attended to. I must also point out that in my opinion the use of such small and thinly-insulated wires carrying high-pressure currents for electric lighting is most injudicious. The cable which failed on this occasion is apparently exactly similar to that which caused the death of a lineman on the House-to-House Company's system rather over a year ago, and other companies have, I am informed, experienced trouble with cables of this size and description.

In order to prevent any recurrence of similar accidents the company should, in my opinion, take the following steps: (1) Immediately replace all cables used for high pressure similar to that which caused the accident by larger cables, having a thickness of insulation of not less than $\frac{1}{16}$in. of best quality indiarubber or some equally efficient material. (2) Connect together all the pipes in which high-pressure cables are contained, and wrap the cables where they pass through street boxes with a sufficient covering of sheet lead, or encase them in iron cases also connected with the pipes, so that the cables should be enclosed throughout in metal casing in connection with earth over the full extent of the system. (3) Submit to the Board of Trade for approval, as required by Regulation 10, some efficient pattern of leakage indicator. 4. Take immediate steps to localise and remove any defect of insulation which may occur on their circuits.

Mr. J. T. King, M.R.C.V.S., reported as follows to the Town Council of Bournemouth:

I beg to report that, acting on your instructions, I have, in conjunction with Mr. Goodall, F.R.C.V.S., of Christchurch, and Mr. Blake, M.R.C.V.S., of Bournemouth, made a post-mortem examination of a grey mare, the property of Mr. Melton, which was reported as having died suddenly, January 8. We found a bruise extending along the right side of the body from about the seventh to the twelfth rib. There was an ecchymosed spot on the corresponding side of the pleura. There was marked hyperaemia of the muscles of the anterior part of the body; the muscles of the posterior part were analmic. The abdominal organs were healthy. The spleen was slightly enlarged; the substance was examined by the microscope and was found to be healthy. The lungs were congested. There was dilatation of the right ventricle of the heart; the valves were normal. The blood was fluid and black in colour. The brain was healthy. Rigor mortis was present. I am of opinion that the post-mortem appearances were consistent with death being caused by an electric shock. I am further of opinion that the dilatation of the heart may have been a predisposing cause of the death of the mare.



The Bournemouth Accident.—Rough Plan Showing Service to Imperial Hotel, Lansdowne Crescent, and Metropole.

The following is the report of Mr. W. Elcock, the foreman:

Carter J. Hooper reports that he went to the Imperial to collect ashes about 7.30 a.m. this morning; when he arrived there his horse became startled, as if by shock, and he says that he himself felt the shock of electricity in his legs, also in his arms. J. Scott, assistant ash-carter that was with him, reported as above mentioned to me. I at once sent him to the offices of the electric light company in the Albert-road to report the same, which he done—viz., to some young person that was in charge of the offices at the time.

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THE
ELECTRICAL ENGINEER.

Published every Friday.

Price Threepence; Post Free, Threepence Halfpenny.

Editorial and Publishing Offices:

39-140, SALISBURY COURT, FLEET STREET,
LONDON, E.C.

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TO CORRESPONDENTS.

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THE DANGERS OF A WEAK HEART.

Some of the daily newspapers have lately created a languid kind of interest in a scare as to the possible dangers of electricity to human life from defective wires or bad workmanship, and if the result should be that the latter become wholly eliminated, the complaints now made—though perhaps exaggerated—will have served a useful purpose.

We imagine, however, that even a "big gooseberry" season would hardly cause a non-technical paper to comment in this fashion upon the somewhat extraordinary incident which lately occurred at Bournemouth, when an omnibus horse lost its life on the street apparently as a result of direct electric shock. One cannot altogether envy Major Cardew his task of endeavouring to find, on behalf of the Board of Trade, a reasonable solution of this occurrence; it is, of course, quite easy to imagine certain conditions under which the incident (the details of which are doubtless fresh in our readers' minds) might justly be ascribed to electric action, but whether such necessary conditions were actually present in the Bournemouth case was the precise point which had to be examined into and reported on by the Board of Trade technical adviser. On another page we publish the conclusions to which he was led after careful investigation on the spot; and from this may be gauged the measure of success he has achieved in finding out the why and wherefore of the matter.

Now that the much-lamented Sherlock Holmes is no longer with us to unravel intricate problems, Major Cardew is, perhaps, to be congratulated upon his analysis of cause and effect in the Bournemouth "mystery," more particularly as he had not the advantage of previously carrying out the synthetical process. There seems to be no doubt—as a result of his investigation—that a slight defect existed in an underground electric light cable carried in an iron pipe near the spot where the unfortunate horse fell down; and it is conceivable in such a case that the iron pipe (which was *not* metallically connected to the large pipes of similar type containing the street mains, but terminated in one side of a brick junction chamber) might become part of the branch circuit in proportion to the resistance of the leak. But one would suppose that an "earth" of this kind, especially on the positive conductor, would at once have made it self-evident in the central station. Major Cardew's explanation of the way in which the leak was, as it were, confined within a narrow area is so ingenious as to be hardly credible.

Not only was the current prevented from passing back to the station through the "electrical cesspool," as it is sometimes facetiously called, or the lower main body of earth lying between the two points, but it was even restrained from traversing the ground surface. In the former case, Major Cardew lays the blame upon the Bournemouth subsoil, truly excellent from a sanitary point of view, but almost useless as an earth return. The second cause of localising the charged area was, he thinks, the frozen condition of the surrounding ground. Apparently, the current was hemmed in without

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possibility of dodging the hard spots where the surface moisture (to a depth of a foot or so) had frozen.

Although such an explanation may quite conceivably hold good, yet we cannot help thinking that Major Cardew showed wisdom, at least, if not a disposition to "hedge," in emphasising the fact that the horse—as shown by the post-mortem examination—could not be considered healthy, or a fit subject for the mildest of electric shocks. If the unfortunate animal's life were insured, we might anticipate a lively discussion as to whether its cardiac dilatation were the immediate or proximate cause of death.

We do not hold a brief on behalf of the electric light company, and would certainly refuse to consider satisfactory their choice of insulation for the branch mains from junction-chamber to transformer-house in the adjacent hotel; but Major Cardew's report is, we think, unduly severe upon them in several respects. It seems that notice had been given, prior to the fatal "horse" incident, of slight shocks being felt at the same spot, and immediate examination was made without result, though the cables themselves were not specifically made. The amount of leakage was so slight that it did not manifest itself in any way at the supply station; otherwise, of course, the whole circuit would have been cut out for a complete test.

The idea of there being practically an insulating wall of frozen ground which encircled the iron pipe and area affected, has such an air of ingenious novelty that one grasps it with interest and a feeling of indebtedness to Major Cardew. As for the poor horse, we have not the least doubt that it was a willing victim in view of what electricity has done and will do for the equine race in tramway work. A would-be humourist has even suggested that, in order to show the gratitude of altruism, the animal fell down so that its Harness might assist in passing a current through its body of sufficient strength to complete the happy despatch.

The question of danger to human life proved, fortunately, outside the mark altogether; and, of course, it would under such circumstances hardly be feared in any way. The leakage of a current at high pressure sufficient to effect bodily injury could not well occur in a manner that would introduce into the circuit any ordinary individual passing along the street, or engaged in duties unconnected with the electrical work. Major Cardew's inquest has therefore been held upon a horse only, and it need not be supposed that at any other time a human being might take the animal's place.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

ELECTRIC LIGHTING AT DOVER—A CORRECTION.

SIR,—In one of the "Business Notes" in this week's issue of the *Electrical Engineer* you call attention to a report by Mr. Slingo upon the Board of Trade by-laws for the supply of electricity in the borough of Dover, stating that "several small alterations were recommended, but the report generally was a strong objection to the proposed sanction of overhead wires." As the paragraph and report have given rise to a wrong impression that overhead wires were intended to be used, permit me to state that had Mr. Slingo made himself acquainted with the tenor of the description of the system to be employed which the Board of Trade requires from electricity supply companies before issuing their permit to undertake the work, he would have ascertained that it was never contemplated to use overhead wires at Dover, and saved himself the trouble of writing a lengthy criticism on a system of distribution so entirely "in the air."—Yours, etc.,

A. J. LAWSON.

London, February 10, 1894.

A PERSONAL EXPLANATION BY MR. KAPP.

SIR,—Your contemporary the *Electrician* contains a note about me which calls for correction, and I would ask you to allow me a little space for this purpose. Perhaps I cannot do better than send you for publication the copy of a letter which I have addressed to your contemporary. It runs as follows:

"Sir,—I saw with much surprise an announcement in your current issue that I am about to leave England. I wonder it has not occurred to you that before publishing a statement which, if erroneous, may injure my professional relations in this country, it would be proper for you to make quite sure your information is correct, and this you might have easily done by enquiry at my office.

"I cordially dislike the importation of personal matters into a scientific paper, but as your statement is calculated to alienate my present and possible future clients, I would ask you to allow me to make the following corrections: (*a*) my leaving England shortly is not even in contemplation; (*b*) my leaving it at a future date (which will give me ample time to finish all the work I have in hand) is in contemplation, but is by no means certain; (*c*) I have been offered an important appointment in Germany, and am in negotiation about it, but the matter is still pending, and will not be settled either way for about a month. Whether I shall leave England or not I do not even know myself at present, so that your statement was certainly premature, and may perhaps also turn out to have been incorrect.—Yours, etc."

It will be clear from the above that the *Electrician* has published as an established fact what is as yet merely a possibility, and I trust you will find space for this letter so that I may set myself right with my professional friends and clients, who might otherwise think it strange that I have up till now kept silent on this point.—Yours, etc.,

GISBERT KAPP.

31, Parliament-street, Westminster, February 10, 1894.

BLACKPOOL CENTRAL STATION.*

BY JOHN HESKETH.

Introduction.—I wish to disclaim from the very first any desire to draw attention to any one system or station, excepting with a view to provoking discussion upon the very broad question of central-station design. If the laying before this society the details of the plant and system at Blackpool conduces to a discussion on this important question, then, as one instance only out of the many of similar design, it may be allowed to retire or merge itself into that particular class of station.

Historical.—So far back as 1879 Blackpool first tried electric lighting by means of Siemens arc lamps each run from a separate dynamo. When it is remembered that the original dynamos and lamps were burning until August last, the character of the work carried out is evident. But the demand for a more general application of electricity to both public and private purposes called for an extension of the scheme, and the Blackpool Electric Lighting Order, 1890, granted powers to the Corporation to lay down works for the supply of electricity from a central station. The town is, as most of the members are aware, long and narrow; the promenade (north to south) being some three miles in length, and the width (west to east) about one mile. The system chosen, therefore, was high tension, and the works were proceeded with on that scheme.

Site.—The building in which the plant is erected is situated in what was the central storeyard, a site in every way suited for the purpose. It is near the centre of the promenade, and

* Paper read before the Northern Society of Electrical Engineers. An illustrated description of the buildings and plant was given in our issue of October 20, 1893.

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a railway siding passes the coal-bunkers. Ample room is available for extensions when necessary. The soil all round Blackpool is mainly peat, in some places being varied by silt and marl. But fortunately there is a mound of clay rising just under the site of these works which enabled us to find solid foundations easily. Clay was met at 3ft. below the ground-level and continued as far as we cared to test, 24ft. being the lowest point tried.

Buildings.—The buildings are erected in two spans—one forming the boiler-house, and the other the engine-room. The boiler-house is 68ft. by 125ft. 6in., and the engine-room 55ft. by 125ft. 6in. As these two buildings run approximately parallel and divide the land, it will be seen that to make extensions is a comparatively easy matter: a false end can be readily run up until any extensions are finished. The chimney is placed in the position indicated on the plan, with a view to facilitating any cleaning of main flues, etc., and of having an equal division of boilers on each side in case of extension southward.

The System.—As before mentioned, the systems adopted are high-tension continuous current for the public arc lighting and high-tension alternating (2,000 volts) for private lighting. Transformers to feed separate installations, or groups, are put down as circumstances demand. The station contains the following plant: (1) 100-kilowatt alternator; (2) 50-kilowatt alternators; (3) Brush arc dynamos, 55 lamps each. The general arrangement of this plant is shown on the accompanying plan.

Details of Plant: Three Double-Flued Lancashire Boilers (manufactured by Messrs. Galloways, Limited, Manchester). Shell, 28ft. long by 7ft. diameter; heating surface, 852 square feet; grate area, 36 square feet; plates 11-16 thick. Butt jointed with inside and outside cover strips. Flues, two in number, 2ft. 9½in. diameter × 15-32in. thick; five "Galloway" cone tubes 10½in. diameter at top, and 5½in. at bottom, placed in each flue. End plates, 11-16in. thick. Fittings, all Hopkinson's own make. Two out of the three boilers are fitted with a combination of Meldrum's forced draught and Proctor's mechanical stoker. The third is fitted with Proctor's stoker only. Feed-water apparatus: Two tanks, each 10ft. high × 7ft. 4in. diameter (capacity 2,640 gallons) are fixed between the boilers. From these the water is fed by two duplex ram pumps, manufactured by Pearn and Co., and capable of delivering 1,500 gallons per hour each. Two feed-water heaters by Fowler and Co., Limited, Leeds, each capable of heating 1,500 gallons of water per hour to 78deg. C.

Engines.—One compound coupled horizontal non-condensing engine, by Fowler and Co., Limited. Cylinders, 15in. and 24in. by 30in. stroke. Horse-power, 200 i.h.p. at 90 revolutions, with steam pressure of 125lb. per square inch. The valves are the ordinary slide valves, the expansion-valves of both cylinders being controlled by Hartnell's patent governors. Flywheel, 14ft. diameter, driving, by eight 1½in. cotton ropes, a 100-kilowatt alternator. Two compound coupled horizontal non-condensing engines, by Fowler and Co. Cylinders, 11in. and 18in. by 20in. stroke. Horse-power, 100 i.h.p. at 120 revolutions, with steam pressure of 125lb. per square inch. Valves as in other engines. Flywheel, 10ft. diameter, driving, by six 1¼in. cotton ropes, a 50-kilowatt alternator. Three compound coupled horizontal non-condensing engines by Fowler and Co. Cylinders 9in. and 14in. by 16in. stroke. Horse-power, 60 i.h.p. at 150 revolutions, with steam pressure of 125lb. per square inch. Valves, as in other engines. Flywheel, 6ft. diameter, driving, by six 1¼in. ropes, a Brush arc dynamo for 55 arc lamps.

Dynamos.—One 100-kilowatt alternator by the Electric Construction Company, 2,000 volts and 50 amperes. Speed, 375 revolutions per minute, at which speed the alternations are 5,000 ⌒ per minute. Current density in armature and field, 2,000 *a* per square inch. Lubrication by special lubricating pumps. Excitation is by a series dynamo, and at full load is 122 volts and 24 amperes, or an excitation of 2·9 per cent. Rope tighteners are provided. One 50-kilowatt alternator by the Electric Construction Company, 2,000 volts and 25 amperes, similar in general design to the 100-kilowatt machine. One 50-kilowatt alternator by the Leeds and London Electrical Company. This alternator is made under the Hall-Hammond patents. It has the advantage of a sectional armature, so that a coil may easily be removed if required. All these alternators run regularly and perfectly in parallel, the synchronising current being small. Three arc dynamos by the Brush Electrical Engineering Company, each capable of maintaining 55 10-ampere arc lamps when running at a speed of 800 revolutions per minute. The special feature of these three machines is that they have been fitted with a new type of brush-holder, which is working most satisfactorily. It is well known that the original type was not all that could be desired, but the present arrangement gives promise of being quite satisfactory.

Switchboard.—The switchboard is of the Lowrie-Hall type, employing plug switches. It has proved eminently satisfactory.

Testing Frame.—For purposes of testing, resistance frames to take 100 kilowatts at 2,000 volts are provided.

Travelling Crane.—One overhead travelling crane for a load of 10 tons spans the engine-room.

Distribution.—The distribution is by means of cables insulated by vulcanised indiarubber. These are drawn into 3in. cast-iron pipes, as many as six cables being drawn into one pipe. Over 20 miles have so far been laid—the furthest point at which a supply is given being two miles distant from the station. The street boxes are of iron or brick, with cast-iron covers, and as the high tides are so frequently over the promenade to a depth of some 2ft. to 3ft., it is useless to try to keep the conduit dry. We find no difficulty, however, in working with the cables under water. The public arc lamps are the Brockie-Pell double-carbon lamps, erected on pillars of a design which is a modification of that in use in the main thoroughfares of Paris. The lamps are burning steadily and well. Transformers are placed wherever possible to feed three or four consumers, but in many instances this is not possible, and a separate transformer for each consumer is fixed. We use at present transformers made by the Electric Construction Company, the Leeds and London Electrical Engineering Company, and Johnson and Phillips.

Meters.—We use the "Shallenberger" and the Thomson wattmeter.

Extensions.—The demand has been so great as to justify our undertaking an extension of plant for private lighting. This will comprise one 100-kilowatt and a 200-kilowatt plant, each with boiler feeding direct, or into the main ring. One feature of the extension is the omission of any special plant for series arc lighting. It is a well-known fact that Mr. Ferranti's latest transformer for commuting alternating into vibratory currents and transforming constant-pressure currents into constant currents at varying potential, is being successfully developed; and it is in the hope that it will prove the success it promises to be, that we are deferring laying down any new arc plant.

Notes on the Working of the Plant.

It is not my intention to go closely into the question of the cost of working the plant at Blackpool. The time has not been long enough for a reliable deduction to be made on this head, but if any value can be attached to them I append the figures taken for four weeks in December, 1893:

	Week ending December, 1893.			
	9	16	23	30
Units output	2,980	2,870	2,830	3,119
Coal	19 t. 5 c.	16 t. 16 c.	16 t. 13 c.	17 t. 12 c.
Pounds per unit	13	13	12·7	12·6
Water, gallons	48,625	31,450	34,530	38,673
Pounds per unit	163	109	122	124

Cost.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Coal	16 15 9	15 7 6	12 5 0	13 11 6
Water	2 9 0	1 12 0	1 15 0	2 0 0
Oil, etc.	1 5 0	0 17 6	0 17 6	0 15 0
Wages	11 1 3	12 6 7	13 12 8	15 0 3
Management and accountants, etc.	7 12 9	8 15 0	7 3 1	7 19 0
Total	39 3 9	38 18 7	35 13 3	39 5 9
Cost per unit	3·15 pence.	3·25 pence.	3·0 pence.	3·0 pence.

Necessarily, a few weeks' readings taken alone, as these are, cannot be taken as any criterion of a year's working, but the first portion of the analysis is interesting. The coal we used during these four weeks was a mixture of Wigan 4ft. and Scotch duff—in the main, not a very good coal, as the majority of the duff was carried over the bridge by the forced draught. Then, again, the banking of the fires is an item for great consideration, as we do not yet run the 24 hours. The water recorded includes that used for every purpose, so that a deduction must be made for cleaning out boilers, etc., if a measure of the evaporative efficiency is to be obtained. If, however, I may be so permitted, I will reserve the question of costs of working this plant for a future communication.

To pass on now to the main point of discussion I desire to raise by this paper. Given an area of supply such as Blackpool, with two classes of lighting, what general design of station is best calculated to give satisfaction? The boilers and steam-raising plant employed are of a well-known and tried type, the engines and dynamos equally reliable; and the only question that is likely to be raised is that of general efficiency and reliability. I strongly incline to the opinion that reliability is worth the sacrifice of a percentage of efficiency ranging from 5 per cent. upwards. With such a plant as this—boilers whose steam-raising capacity is known to a nicety, engines that will run for months without a stoppage, and dynamos on which a coil scarcely ever goes—an engineer can regard almost complacently a plant efficiency of 65 to 70 per cent. Then, too, the question of parallel running is one which must bias the design of a station. If it is necessary with some dynamos to put a marine type of ammeter on the circuits to prevent the synchronising current from being too apparent, while with others the lightest of pointers scarce moves over five scale divisions, then the difference in the result on the dynamos

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themselves after 12 months continued parallel running must be evident.

The question of distribution is one having many aspects. The advocates of the simple two-wire system have now many opponents, but with a high-tension network designed to feed each transformer from two directions, and with banked transformers feeding into a similar low-tension network, the variation in voltage (which, after all, is the public's criterion of successful lighting) is reduced to a minimum. The question of mains, and their insulation, too, is viewed differently by different engineers. My own opinion is that it is useless endeavouring to lay watertight conduits, and that the endeavour should be to have cables to run as well in water as out of it. High-insulation resistance is an admirable thing, but it can be obtained in too many ways to be satisfactory in itself. It is with a view to provoking discussion on these general questions of design that I venture to mention in detail a few of the alternatives offered to the plan adopted by us at Blackpool. To begin with the

Boilers.—The advocates of multitubular boilers are numerous. They claim a higher all-round efficiency and economy in space. But I question whether all their contentions are maintained in practice. There are stations where, after having used multitubular boilers, it is found advisable to lay down Lancashire boilers to take the real duty of the station and leave the multitubulars for rapid steam raising. With efficient feed-water heaters, or good exhaust-steam injectors, and a well-tried mechanical stoker, I question whether the old type of Lancashire boilers can well be beaten.

Mechanical Stokers.—The type of stoker used by us is that manufactured by Mr. J. Proctor, of Burnley. The alternatives brought before us were Bennis and Vickers's stokers.

Steam Ring.—The steam-pipe is erected, as will be seen from the plan, on the ring principle, each boiler feeding into the ring. By this means each engine can be fed from two directions, and risk of breakdown is reduced to a minimum. The alternatives suggested are many. One is to feed direct into each engine from its own boiler with by-passes in the event of a boiler or engine being laid off. This system has its advantages, but I incline to the opinion that the ring is preferable.

Engines.—In approaching the question of engines, I am aware that the field for discussion is very wide indeed. Slow-speed horizontal, moderate-speed verticals, central-valve verticals—all have their advocates. But it must be remembered that Lancashire is, above all places, the home of slow-speed horizontal engines. It is only natural that where space is available, the tendency should be to adopt that class of engine which for regularity and reliability has so long proved its fitness in this and other districts. I am led to believe that central-valve engines require somewhat skilled labour and careful supervision, whereas any Lancashire mechanic is sure to have had years of experience with slow-speed horizontals. Moderate-speed verticals are beginning to gain ground fast, and they, if any, are the rivals of the slow horizontals, especially where space is a consideration and direct coupling is desired.

Rope Driving.—Here again is a fruitful source of controversy. The question resolves itself into (1) three-strand, as against four-strand ropes; (2) separate ropes for each groove, as against an endless rope with a jockey pulley. The advocates of each of these systems naturally say their own is best, but it is for practice to have the last word. We find three-strand ropes to run very well indeed. Some turn round in the grooves, while others do not. Direct coupling is, however, coming much to the front. Its advocates claim, and with some amount of truth, a considerable increase in efficiency as against rope driving. Reliable data on this point will be much welcomed.

Alternators.—I have previously stated my opinion that I consider reliability to be worth from 5 per cent. efficiency, and that good parallel running is another important factor. The alternators of the type we have here run most perfectly in parallel. I have never seen machines take less synchronising current. Of course, with all alternators running in parallel a great deal depends upon the engine. It is not so important to regulate by the excitation as by the engine stop-valve; and experiments in parallel running fail frequently because the dynamo speeds are not similar before paralleled, and therefore, after paralleling, one engine is constantly trying to pull itself out of step. It is a mistake electricians are prone to make—this regulating from the dynamo end simply—but it is not a successful way. The points one would most wish to have a clear and settled opinion upon as to alternators are: What efficiency should we reasonably expect an alternator to give? How long should it be able to run (at that efficiency) before a coil goes, or a breakdown occurs; and what synchronising current should be aimed at as good practice? It is not good enough for dynamo-builders to say, "This efficiency is indispensable; never mind coils going, they can be easily replaced." We who run central stations want dynamos that will run the year in and out without the crane once being near it, and if we can incidentally obtain 91 or 92 per cent. efficiency so much the better. But if we buy this efficiency at a cost of a stoppage once a month, or even once a quarter, it is dearly bought. Credit before efficiency; but both if possible.

Switchboard Arrangements.—Under this head, of course, are included all instruments for measuring the output. This important feature is often dealt with by simply taking quarter-hour readings, averaging out, and finding the apparent watts. But although this may be an approximately correct method on circuits with small magnetising currents, it is not satisfactory even with them, and on circuits where both alternator and transformer have a sensible induction it is far from accurate. We employ a Thomson wattmeter on each circuit to check the readings taken every quarter of an hour. The error in apparent watts over the watts recorded by the meter vary from 5 to 15, or 20 at lowest loads. The Mangarini wattmeter is another form which I believe very good for this purpose. Our voltmeters and ammeters are all Nalder's make. These we check periodically by the standard dynamometer and multicellular voltmeter.

Mains.—The draw-in and draw-out system has many advantages over the buried conductor. But there are now many cables competing with those insulated by vulcanised indiarubber, so that even with a draw-in and draw-out system there are many alternative cables to decide between. Single and concentric each have their advocates—indiarubber, guttapercha, and paper, as insulation, each having advantages of their own. The only serious rival of indiarubber-covered cables, to my mind, is the paper insulation of Mr. Ferranti's. Made up in concentric form and lead covered or steel taped, this cable seems to stand any working pressure. But vulcanised indiarubber will do this if the best rubber be used, and it is only on the point of lasting qualities that one can make the crucial comparison. As I before said, our cables are and have been running under water for some time, and we have had no trouble with them. The same thing can be said, I believe, of paper insulation; and were it not for the established repute of vulcanised indiarubber, I can easily conceive that paper would be an even more serious rival to it.

It has been with the hope of eliciting the experiences of the members on these various questions that I have ventured to place this effort before them.

Discussion.

Mr. Fawcus, after complimenting the author on his paper, said that some short time ago the question between high and low tension seemed to be rather going in favour of the low-tension system. One successful station had influenced many others, and it seemed to be tending in that direction, but now better counsels had prevailed, and the high tension was fast gaining ground. On the particular system discussed that night he would like to ask Mr. Hesketh how the double service to each consumer was laid? If it meant laying special mains to get a double service, he did not consider it worth the extra cost. The question of parallel running, too, had never yet been settled, and he, like Mr. Hesketh, would like some basis on which they might work. On the question of boilers he considered that Lancashire boilers were far preferable to multitubular boilers, except for rapid steam raising. For general work and efficiency he considered that nothing could beat the Lancashire boilers. He did not quite agree that direct coupling was the advantage that it was claimed. It immediately necessitated high speeds in the engine and lower speeds in the dynamos, and therefore lighter working parts in the engine, and heavier and more expensive make of dynamo. But in cases where space was the great consideration, moderate slow-speed vertical engines might be found of advantage.

Mr. Rider said he would like to ask one or two questions, although he was scarcely prepared for extensive criticism. He presumed that the points raised by Mr. Fawcus as to the double service to each consumer or bank of transformers was gained incidentally, and that no special mains had to be laid. Next as to excitation. If the field magnets are excited by constant current, why should any false watts be present? He rather gathered that at present no low-tension network was laid. Was this so? He would also like to know how the pressure was maintained constant and an indication given from the far end of the mains. He noted that each dynamo had its own exciter, and asked if it were necessary when running in parallel to regulate by each exciter, and if it would not be advisable to have the field magnets excited in parallel, so that one regulation would serve for all the machines? Commenting upon the Hall-Hammond type of alternators, he asked if the fact that the armature coils were wound on projecting laminated pieces caused any fluctuation in the exciting current?

Mr. Browett said that the question of horizontal or vertical engines was often decided by the makers by the consideration of space. The same could also be said as regards ropes as against direct driving. He considered that a moderate-speed vertical engine having the few working parts of the horizontal slow-speed engine, was in some instances preferable.

Mr. Corlett considered that there was a great deal to be said in favour of direct coupling. One incidental advantage for a place like Manchester was the ease with which the plant could be started. He disagreed to some extent with the advocates of high-tension systems. He considered that the low-tension system was far more simple, and that the maintenance of the insulation of the mains was easier. Again, both motors and arc lamps could be more successfully run off low-tension direct-current mains. He did not think that any alternating-current motors of a periodicity

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above 40 were to be got. Then, again, the necessity for the constant day load made the use of a battery a great convenience in a low-tension station.

Mr. Cowan spoke as to the efficiency of condensing as against non-condensing engines, recapitulating the figures given by Mr. Willans as to the saving at full load of 18 per cent. and at low loads of 40 per cent. On the question of boilers he considered that we should not lose sight of the fact that Lancashire boilers required more time to get up steam. He would like to know what pressure of forced draught was used at Blackpool.

Mr. Fawcus mentioned that he had that day received particulars of the Gothenburg station, where the average amount received from the consumers was 2¾d. per unit, and even at this revenue the company was paying 5 per cent., and that with coal dearer than it is in Lancashire.

Mr. Hirst would like to know how the meters in use at Blackpool worked, and further details of them. Speaking on the question of motors, he had just returned from Switzerland, where 1,200 h.p. was being distributed on the alternating system of mains by motors varying from $\frac{1}{10}$ h.p. to 10 h.p. He mentioned the system used by the Oerlikon Company, who employed the condenser in starting their motors, and switching over after attaining synchronism.

A Member spoke on the saving of labour by using direct coupling. With direct coupling one man could generally manage three sets of plant, whereas with rope driving it generally required one man to each set. He understood that with direct-driven plant there was considerable difficulty in running in parallel, and that at Bristol and Derby coils had given out on attempting to so run. He would like to have an expression of opinion as to the points to be observed in parallel running.

Mr. Lindley said that he would like to make a remark or two as to the running at Bristol and Derby. There were two ways open for them to obtain varying motions on the cranks. One was to have the cranks directly opposite, or at right angles; the other was to throttle the steam to some extent. But he was more than ever struck with the uncertainty still existing on the subject of parallel running. They had tried heavy flywheels and light flywheels at Derby, and although they had run in parallel it was only after some difficulty. He would like to know whether the difficulty was with the dynamos or with the engines.

Mr. Hesketh, in reply, said that many of the points were of extreme importance and interest. Some of them called for specialists' attention rather than for his, but he would endeavour to reply to the majority of the questions asked. Replying to Mr. Fawcus's query as to the double service to each transformer substation, it was gained incidentally. Most blocks of buildings are built in squares, and when all shops require a service it is very easy to feed each transformer both ways. He thought that two of Mr. Rider's questions bore upon each other. Mr. Rider asked how it was that a constant current should not give true watts when the current and the voltage were multiplied, but later asked, did not the armature react on the field magnets in the Hall-Hammond type? It was observing this reaction which led to the investigation of the false watts in excitation. Mr. Hesketh agreed with Mr. Rider that in parallel running it was better to regulate the field magnets in parallel. He could not quite agree with Mr. Corlett's contention as to the superior simplicity and flexibility of the low-tension system. Neither was he quite sure that the insulation of low-tension mains was more easily maintained. He believed that there were representatives of low-tension systems present who could speak better on this point than he could, but for the simplicity of the high-tension system he could speak. Mr. Corlett had said that there were no alternating-current motors to be got, whereas he had received almost weekly offers of alternating-current motors from $\frac{1}{10}$ h.p. to 8 h p or 10 h.p. for alternating currents of a periodicity from 40 to 120 On the question of the use of batteries and shutting down the station for the load to be taken by the batteries, he thought he was quoting the words of Mr. Siemens, who some two years ago said, "that batteries would only be used in toy stations to feed restricted areas," and that for their extended use he had not much faith. On the question of parallel running, referred to by Mr. Browett and Mr. Lindley, some electricians said it was purely a mechanical failing when alternators would not run in parallel. Some mechanical engineers said it was purely an electrical fault. He considered it was both. Alternators were to be seen running in parallel driven direct by central-valve engines, by vertical engines, and by slow-speed horizontal engines The alternators, too, varied in type, and might have a revolving field with an armature, in which there was no iron, as in the Mordey alternator; others with iron in the field, such as that of the Hall-Hammond type. He believed that the experiments made in the four city stations recently proved that half-a-dozen different types of alternators driven by an equally varied number of engines would run well in parallel. One point was worth noting in this question of parallel running Given a slow-speed horizontal engine with perfect valve gear, and with a card approximating to a theoretical figure where the cut off was sharply defined, the compression slight, and the admission line perfectly sharp, if it only had a light flywheel, and was driving an alternator without iron in the armature, he doubted whether parallel running could be attained; but if a vertical engine with a very imperfect diagram in which the cut off was ill-defined, where compression was great, so that the admission line was scarcely more than a pound or two, then if they were driving an alternator similar to the previous one it would run in parallel if proper precautions were taken. But the first engine would drive alternators of a certain type in parallel. It was a question both of the mechanical power and of the electrical capacities of the dynamo. He believed he was right when, with reference to the Bristol and Derby difficulties, he attributed some of the difficulty at least to insufficient care in arriving at perfect synchronism before paralleling the alternators. The two alternators might be running exactly at the same speed, but one might be a fraction of a phase behind the other. The synchronising current when paralleling would be sufficient to blow the fuses, and it was only when they had the maximum points of the peaks exactly coincident, and the speeds absolutely equal, that it was possible to parallel successfully. Some alternators would pull themselves together in paralleling with a large synchronising current; others would not. The fact that coils had given out at Bristol and Derby accentuated the importance of having some fixed data on which to work as to mechanical strength *versus* high electrical efficiency.

A vote of thanks terminated the proceedings.

INSTITUTION OF ELECTRICAL ENGINEERS.

SOME NOTES ON THE ELECTRIC LIGHTING OF THE CITY OF LONDON.

BY MAJOR-GENERAL WEBBER, R.E., C.B.

(Continued from page 169.)

Capital Expenditure.

The question of raising capital for electricity supply companies has not differed much in its conditions from other sister industries. This paper would be less instructive if that part of the subject was overlooked, and it is noteworthy that, even with a field for the supply of electricity in which the gas company had a gross income of over £370,000.* Even in 1891 it was not thought prudent to do what is called "go to the public," in the first instance, with a plainly-stated prospectus. Such a statement most certainly would have shown that the supply of electricity to the City should be an undertaking affording as sound an investment as could be found anywhere, and also one which at an early date, under the operation of the sliding scale already alluded to, would allow of the cost of the current being reduced below the maximum of 8d. As we all know, a very old way of commencing to raise capital has been brought out under a new name—namely, by the starting of a "pioneer company," which is one way of getting an instalment of capital together to make a beginning. Of course, there is no engineering justification for it, but the financial physician has prescribed it, and hence this first capital must be spent with a primary object of showing that something can and will be done. The future of the undertaking from the structural point of view may become quite a secondary consideration, and, indeed, may be ignored if it interferes with the parade with which it is intended to "draw" the investing public. They (the public) have only themselves to thank if this sort of thing is necessary. Engineers and contractors have no real interest in its existence. The contracts with the Commissioners for the public lighting of the City were dated: for the eastern district, May 28, 1890; for the central district, May 19, 1890; for the western district, February 5, 1891. And they required that the main thoroughfares should be completed with arc lamps in the eastern and central districts by February 28 and 19, 1892, respectively, and in the western district by November 5, 1893. The "first sod was cut" on January 5 1891, when a junction-box was constructed on the west side of the Mansion House, with an inscription inserted in the wall. The first street was lighted in July, 1891. The arc lighting generating plant was permanently fixed in the pioneer buildings, but in other respects the installations were designed to be temporary. The two companies—namely, the Brush Electrical Engineering Company, and the Laing, Wharton, and Down Construction Syndicate—to whom, as has been stated, the provisional orders and contracts had been granted, had in February, 1891, transferred their interests, through an exploration company and an electric and general investment company, conditionally, to the City of London Pioneer Company, of which company I was appointed the engineer after the contracts had been made. These interests included the obligation to complete the purchase of sites for generating stations—one at the Wool Quay, in Lower Thames-street, the other at Meredith's Wharf, in Bankside.

Part of the consideration for the transfer of the responsibilities and liabilities of the *concessionaire* companies was in each case a provisional contract for the supply and erection of the entire plant and equipment of one temporary (or pioneer) and one permanent generating station for the supply of current to, and for the transforming of current in, each district. In similar cases the work of pioneer companies has been confined to the task of financing. Unfortunately, I think, in this case the City of London Pioneer Company had to undertake actual work, so far as the public lighting was concerned, because the time remaining—namely, about 12 months—in February, 1891, when the contracts for the central and eastern districts had to be completed, was even then very short. But these provisional contracts for temporary work

* The day and night populations of the City, respectively 261,061 and 50,652 in 1881, had altered in 1891 to 301,384 and 37,694 The day population, as compared with counties and towns in England and Wales, is larger than 26 counties, and all other towns except Liverpool, Manchester, Birmingham, Leeds, and Sheffield. Before 1891 there were 3,136 public gas lamps, costing £10,530 per annum.

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included some private lighting;* the object being the old-fashioned one, to create a display, in my opinion, at the expense of good work, and with the risk of a legacy of trouble, anxiety, and failure. Suffice it to say that in spite of every possible precaution to prevent it, no small part of this temporary work has had, or will have, to be moved or altered after having been put to work; and a large part of the money spent on these temporary installations—amounting, together with other expenses, to a very considerable sum—must be more or less wasted.†

On July 13, 1891, while the pioneer contracts were still uncompleted, all the interests acquired by the pioneer company were taken over by the City of London Electric Light Company for a further consideration, by which means the lighting of the City was, with the consent of the Board of Trade and of the City authorities, amalgamated into one undertaking instead of three, and it was at last possible to begin work in earnest, with a hope that the words "temporary" and "provisional" were past. The estimates for works upon which the capital of the new company was raised amounted to: buildings, £53,000; equipment of the three stations, £493,250; distribution, £342,850—total, £889,100. This was exclusive of the cost of the sites. The contracts for public lighting with the *concessionaire* companies which had been taken over from the pioneer company besides providing for the supply and installation of the plant and equipment for one station for each district of the City, provided also the arc and incandescent lamps for the public lighting, with their fittings, exclusive of posts and lanterns, in every respect sufficient to enable the new City company to fulfil the terms of the contracts with the Commissioners of Sewers, as follows:

Eastern district. (Laing, Wharton, and Down Company.)		Central district. (Brush Electrical Engineering Company.)		Western district. (Brush Electrical Engineering Company.)	
Arc.	Incandescent.	Arc.	Incandescent.	Arc.	Incandescent.
233	307	138	302	144	297
Total arc, 515.		Total incandescent, 906.			

Besides this, the contracts between the same parties required the work to be done for equipping the stations and providing the plant for the supply and conversion of current for private lighting to be in accordance with detailed specifications and schedules of prices. It was agreed that these details and prices were to be laid down afterwards and settled between the engineer of the company and the contractors; differences (if any) to be referred to Mr. Preece. The contracts required that the output of the Brush stations for the supply of the central and western districts, and of the Laing, Wharton, and Down Company's station for the eastern district, should, including the pioneer plant, be as follows:

	Public and other arc lighting. Kilowatts.	Private lighting. Kilowatts.
Eastern district	450	4,800
Central ,,	330	3,900
Western ,,	220	3,400
	1,000	12,100
		1,000
Total kilowatts		13,100

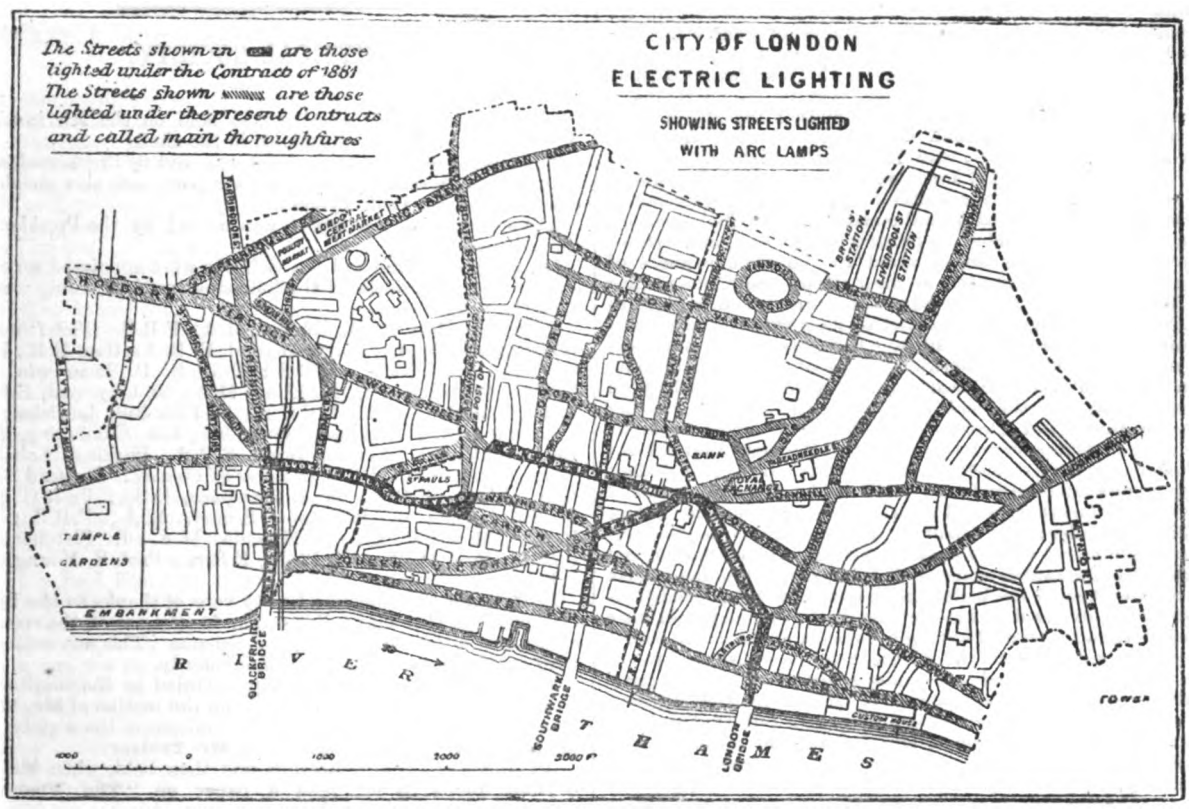
The Streets shown in are those lighted under the Contract of 1881
The Streets shown are those lighted under the present Contracts and called main thoroughfares
CITY OF LONDON
ELECTRIC LIGHTING
SHOWING STREETS LIGHTED WITH ARC LAMPS
HOLBORN
TEMPLE GARDENS
EMBANKMENT
BLACKFRIARS BRIDGE
SOUTHWARK BRIDGE
LONDON BRIDGE
BANK
R I V E R
T H A M E S

FIG. 1.—Map of all City, with thoroughfares marked.

Adding together the cost of the contracts and estimates, and dividing by the total of 13,100, we obtain the following total cost per kilowatt:

Preliminary expenses	£8,000
Work done by the pioneer company, including some work of distribution	46,000
Extras on ditto	10,000
Contracts for the stations	493,250
Estimate of cost of completing distribution	342,850
	900,100
Add 8 per cent. for the cost of the sites of the generating stations	72,008
Total	£972,108

Namely, total per kilowatt, nearly £75.

Anyone present will realise that the preparation of detailed specifications for the equipment of an electric light supply station, both for generating and transforming requires the fullest technical description. Besides that of the boilers, engines,* and dynamos,

*The first current for private lighting was commenced on December 11, 1891, to the Mansion House, but it was more than six months after before the plant could be run during daylight hours.

† I had been through such troubles in connection with electrical and other engineering too often not to throw all my weight into the scale against temporary work of any kind. It is only before an assembly of engineers that an engineer can hope to find any appreciation of such a situation. Neither financiers nor contractors sympathise with his efforts to prevent unnecessary expenditure, except so far as it affects their own interests. The financier does not mind so long as the total expenditure is within his estimates of what the investor will stand; and the contractor need only care if he is going to accept any payment in shares, and not always then. Besides this, there is the long series of harassing engineering consequences arising out of crude, hasty, and ill-considered work preliminary to a great undertaking. Many of us have been through it, and learnt to take it as part of the day's work; but, all the same, it is always regrettable.

* Prof. S. P. Thompson's opinion, in November, 1891, on the types of engines which the contractors, under the restrictions and definitions contained in the specification, proposed to adopt, was that, while expressing his own opinion on the advantages of triple expansion, and of engines of the closed type, he confirmed entirely the conditions that the choice should be of the vertical and direct-coupled type; he postponed his final opinion until six months' running of the first group of 400 kilowatt units had been completed. It is to be hoped that he will be able now, more than two years having passed, to give electrical engineers his further experience in the subject.

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there are the questions of the arrangements for transport and conveyance of coal and refuse, economising, condensing, and stoking; there are also the details of foundations, drains, subways, travellers, lifts, cranes, and the lighting of the station, as well as telephonic communication with, and equipment of, transforming sub-stations. I need not say that the preparation and agreement as to the details of specifications, after a contract is made and the total price to be paid is fixed, is a somewhat novel task for the engineer of the spending company. In this case the putting of the cart (as it were) before the horse fortunately did not end in miscarriage. The engineers on both sides* were anxious, while doing justice to their employers, to arrive at a fair and reasonable solution, and Mr. Preece could tell you that it ended in only about half-a-dozen points of difference between them and me having to be referred to him, in specifications containing nearly 120 pages of closely-printed matter. In these specifications, although the specialities of the two contracting firms were well known, nothing was laid down to confine them to their own particular make of engines, boilers, dynamos, transformers, and lamps. The contractors described to me the sizes of the units they desired to employ. They are not limited to any particular form of driving, and, as far as possible, to produce uniformity, the speeds and electrical conditions which they desire to use are allowed. Economising, automatic stoking, and condensing, and all possible accessories—including testing and switch-room apparatus and fittings—are required of capacity equal to the full output of the plant.

All the conditions of the different stages of generating are rigorously prescribed so far as the results under test are concerned. For instance, it is laid down in the specifications that, after providing for all extraneous steam consumption and waste, the standard of consumption of coal, including the steam used in the condensing pumps, shall not exceed 5lb. for the high-tension alternating currents, and 7lb. for the high-tension continuous currents, per Board of Trade unit delivered at the terminals of the primary mains in the stations. Amongst the extraneous uses of steam to be excluded from the above basis are included that used for the power expended in moving water, coal, and refuse. The tests to prove this are adapted to the circumstances of running the station†—a matter, as most of us know, not always easy. Therefore their nature and number are to be subject to the approval of the engineer, so as not to clash with the conditions of statutory supply from the station. The tests of each unit estimated to have an output of 400 kilowatts, or of each group of units with an output of 1,200 kilowatts, are necessarily dependent on the circumstances of the load on the station. The alternating plant—both Brush and Thomson-Houston—was experimental at the time the contracts were made, therefore the first examples had to be under trial for six months. These trials had to be coincident with the supply, and dependent on the load on the station, and the contractors for that period were to be responsible for failure of all kinds. Under strict penalties, the contractors are answerable for the dimensions of foundations, flues, and chimneys, and are required to guarantee absence of vibration, noise, and smoke nuisance. As regards the boiler tests, under the usual conditions of temperature, external and at the base of the chimney, and state of barometer, and with coal having a calorific value of 13,500, it is obligatory that 77 per cent. of the heat is transferred to the water by the boilers and economisers together. As regards the consumption per horse-power of steam in the engines, the Brush Company have agreed to a limit with full load of 22lb. of steam exhausting to the atmosphere, and 18lb. when condensing. The Laing, Wharton, and Down Company have agreed to a limit of 20 and 17 respectively. For the commercial efficiency of the electrical 400-kilowatt generators, 80 per cent. when working at full load is prescribed, 2 per cent. of that only being allowed to be absorbed in the excitation. Besides, there was given a description of every test which each portion of the plant would be required to sustain. At the same time the widest latitude as regards design throughout the whole of the station plant and accessories is allowed.‡

I do not know if the meeting considers if any better way could be adopted for protecting the expenditure of capital and stimulating the energies of contractors, after it had been decided by others how much should be spent, how much should be the maximum output of the plant, and who were to be the contractors. What was probably one of the most difficult parts of the task was the description of the details of the adaptation of portions of the plant to sites and buildings still under design, so that no extras on the contracts should arise, and thus the equipment of the stations and sub-stations should be of the most complete and up-to-date description, and fully equal to the requirement of the capacity which the contractors had undertaken to provide. Both sites presented exceptional features, and the designing of the building structures for each differed entirely. That for the Wool Quay (since abandoned)§ required a building in which the floor of the basement would have been 20ft. below high-water mark, and the station plant should be placed on floors one above the other; the generators to be in the basement, the boilers over (on a Hobson's steel-girder floor), and the coal above.

The site at Meredith's Wharf, although the essential features of the first design have been retained, has been so enlarged that any description of it that might be attempted in this paper would not be sufficient.*

The estimate of the load factors of the public lighting of the City may be here made with some interest. Adopting Mr. Crompton's figure, which allows 25 per cent. for extra or reserve machinery, in the case of the public lighting the capacity of the plant is 890 - 222 = 668 kilowatts, or 5,851,680 kilowatts per annum. The 515 arc lamps represent 257,500 watt-hours, and the 906 incandescent lamps—half being 100 watts, and half 50—represent 67,950 watts more, or a total hourly consumption of 325·45 kilowatt-hours, which, with 4,030 running hours in the year, gives a load of 1,311,562 units per annum. But, in fact, the amount of the above plant that is spare or available for arc lighting in public buildings and elsewhere is very large, and it is better to regard the actual capacity of the plant exclusively devoted to public lighting, including reserve, as represented by 16 50 (500-watt) light machines, with an annual total capacity of 3,504,000 kilowatts. This will give a load factor of 37·4.

(To be continued.)

* Mr. Raworth and Prof. Kennedy, assisted by Mr. Wharton, represented the two contracting companies, while I represented the City of London Electric Lighting Company.

† The contractors could not provide means of running their large dynamos at their works. All real tests had to be made after delivery. This was an inherent difficulty for the engineer.

‡ The essence of these specifications was that, except in respect to a few points not within the scope of the contractors' work as electrical engineers, all details of design were left to them, subject to the final approval of the engineer.

§ This site had to be taken over by the City Company under the *concessionaire* contracts.

* The Institution will be better served if I leave it to the gentlemen who were selected by me as my assistants for that part of the work, and who have actually since carried it out—namely, Colonel Seddon (late R E.) and Mr. C. Thompson. The meeting will, I hope, understand that in refraining to give any detailed description of the equipment of the stations I am influenced by the wish that such should be undertaken either by the engineers of the respective contractors who designed and erected them, or by Mr. J. H. Jackson (one of my assistants), who is still superintending the same. As regards the building structures, I may, however, add that of three chimneys designed, and specified and contracted for under me, one—*i.e.*, that now to be seen close to Bankside—has been erected. There are features of its construction, especially with reference to the bond, that I should like to have time to describe. Its cost was £2,075, its height 150ft., and its internal diameter 12ft.

PHYSICAL SOCIETY.

The annual general meeting was held on the 9th inst., Prof. A. W. Rücker, F.R.S., president, in the chair.

The annual report of the council was read by the President.

Dr. Atkinson read the treasurer's report, and also an obituary notice of the late Prof. Tyndall.

The adoption of the report was moved by the President, and carried *nem. con.*

Dr. Chichester Bell and Mr. Griffiths were appointed scrutators, and subsequently declared the following gentlemen duly elected to form the new council.

President: Prof. A. W. Rücker, M.A., F.R.S. *Vice-Presidents*: Walter Baily, M.A.; Major-General E. R. Festing, R.E., F.R.S.; Prof. J. Perry, D.Sc., F.R.S.; Prof. S. P. Thompson, D.Sc., F.R.S. *Secretaries*: H. M. Elder, M.A., 50, City-road, E.C., and T. H. Blakesley, M.A., M.I.C.E., 3, Eliot-hill, Lewisham, S.E. *Treasurer*: Dr. E. Atkinson, Portesberg-hill, Camberley, Surrey. *Demonstrator*: C. Vernon Boys, F.R.S., Physical Laboratory, South Kensington. *Other Members of Council*: Shelford Bidwell, M.A., LL.B., F.R.S.; W. E. Sumpner, D.Sc.; Prof. G. Fuller; J. Swinburne; G. Johnstone Storey, M.A., F.R.S.; R. E. Baynes, M.A.: Prof. G. M. Minchin, M.A.; L. Fletcher, M.A., F.R.S.; Prof. O. Henrici, Ph.D., F.R.S.; Prof. S. Young, D.Sc., F.R.S.

Prof. Reinold proposed a hearty vote of thanks to the Lords of Committee of Council on Edueation for the use of the rooms and apparatus in the Royal College of Science. This was seconded by **Prof. J. V. Jones** and carried unanimously.

Votes of thanks were similarly accorded to the auditors, Mr. A. P. Trotter and Mr. R. Inwards, on the motion of **Mr. Watson**, seconded by **Prof. Fuller**, and to the officers of the society, on the motion of **Dr. Burton**, seconded by **Mr. Trotter**.

An ordinary science meeting was then held, when **Mr. Owen Glynne Jones, B.Sc.**, read a paper on "**The Viscosity of Liquids**," and exhibited the apparatus used in his experiments.

COMPANIES' MEETINGS.

KENSINGTON AND KNIGHTSBRIDGE ELECTRIC LIGHTING COMPANY, LIMITED.

The seventh ordinary general meeting of the shareholders of this Company was held at 1, Great George-street, Westminster, yesterday (Thursday) afternoon, Mr. Granville R. Ryder occupying the chair.

The **Chairman**, in moving the adoption of the report, stated that it was very satisfactory, as it gave 1 per cent. extra dividend and offered good prospects. It was very pleasing to find that there had been an increase of one-third in the amount of

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electricity supplied at an increase of only one-sixteenth in expense. With regard to the gross and net earnings, the latter showed a very favourable comparison with the former. So far only the fringe of the business in the districts had been touched, and there would be no fear of the limits having been reached. There were many private houses in the district which had not yet adopted electric lighting, and which would be sure to so later on, and residential flats were being erected which would prove safe customers. The time might come when they would have to reduce their prices for electricity, but he had no fear of that deleteriously affecting the Company, because a reduction in price would be followed by an increase of business. The capital account had been increased by nearly £20,000, which had been spent on the freehold of Kensington Court station, on machinery, mains, and meters, and on purchasing an area of supply from the Chelsea Company. The directors have written off as much as possible in justice to present shareholders.

Sir Frederick Bramwell seconded the adoption of the report.

Mr. J. F. Albright, who mentioned that the report stated that no provision had been made in the accounts for directors' remuneration, moved that they receive £500. This was seconded by **Mr. Killingworth Hedges** and carried.

Messrs. R. W. Wallace and Mr. A. S. Bolton were re-elected directors. Messrs. Lovelock, H. W. Whiffin, and Dickinson were reappointed auditors, their remuneration being increased from thirty to fifty guineas.

NEWCASTLE AND DISTRICT ELECTRIC LIGHTING COMPANY, LIMITED.

The seventh ordinary general meeting of this Company was held on Monday in Newcastle, Mr. J. D. Milburn (chairman) presiding.

The **Chairman**, in moving the adoption of the report and accounts (which were given in our last issue), said they had had a very great increase in the amount of work they were doing. They had had an increase of nearly 100,000 units of electrical energy during the year. That came partially from the North-Eastern Railway Company, at the station and other works, but also to a large extent from individual consumers. That must be looked upon as very satisfactory, because the more work they got to do, the more it consumed of their standing charges, and the more profit, up to a certain degree, it allowed them to make. They had been able to effect considerable economy in coal consumption. The drift to the river, and the condensing plant, introduced by Mr. Parsons, had been a very great success, notwithstanding that the cost had been greater than they anticipated. The difficulties of sinking and tunnelling down to the river were, of course, unknown quantities to begin with, and did not come out quite as they expected, and they had to spend a little more time and money in getting at it. They had got at it now, and it was answering their highest hopes in the direction of economy. They had considered the question of utilising town refuse as fuel. Some remarks were made about it at their last annual meeting, and it was found possible not only to do a good deal with the fuel, but also to set up a paper factory alongside the works. But Mr. Parsons, who had gone into the matter thoroughly, pointed out that, with duff coal at 3s. or 3s. 2d. per ton, very little economy could be got with anything of the kind. The fuel was all very well—it would burn, but it took a lot of labour to shovel it on to the fires; and if they could get their boilers singing away at full pressure with coal as low as 3s. 2d. per ton, they could hardly go into a question such as that. There was another matter which went into the question of cost. They would see in the gas company's report that the directors said that the policy of reducing the price to 1s 10d. per 1,000 cubic feet had not fulfilled the expectations they formed of it, and that they were going to put the price back again. It was calculated in electric lighting that 6d. per unit was equal to 5s. per 1,000ft. of gas. But the more they had opportunity and experience of knowing how the light was used, the more they were convinced that a great deal of waste took place in electric lighting. Now that the new lamps had come in, this had to a certain extent disappeared. He felt that they were approaching the day when the cost of the electric light would assimilate itself with that of gas. There was the question of the reduction of their own price. They did not feel quite yet that they could recommend it; they had had no complaints. Gradually their customers were waking up to the better use and idea of the economy of the electric light, and they hoped that that would popularise the idea of the light. They had said so much about the beauties of the one light as compared with the gross impurities of the other, that he did not think he need go into it again that day. But they wished their customers to know that less lamp power would give them a good enough light. They had recommended the same dividend as last year. Probably they might have done a little more, but they felt that they might some year have drawbacks, and they might have some bad luck; and it was only right that they should be prepared for that. The feeling of the directors was that they should not go backwards. If they got 6 per cent. this year, it would not be pleasant for the shareholders to go back to 5½ or 5 per cent. another year. They had applied to the local stock exchange for a quotation, and he would ask them to adopt certain alterations in the Company's rules, as required, with the result that very shortly the shares would be quoted in the local list, and anybody who wished to buy or sell shares would have every facility for doing so.

Sir B. C. Browne seconded the adoption of the report.

A **Shareholder** directed attention to the recent statement that the Corporation were thinking of obtaining the electric supply into their own hands. Would not that, he asked, mean serious competition with that Company?

The **Chairman** said they had heard nothing officially about that matter. The Corporation would have to agree with the Company as to a price for their undertaking, to buy them out. The Company, when seeking their provisional order, made a bargain with the Corporation as to limiting their dividend, and the Corporation would have very great difficulty in going to the Government to get an order themselves. Both the electric lighting companies would oppose them. The Corporation could not compel them to sell before the expiration of 30 years.

Councillor A. Fox, referring to the question of utilising the town refuse, said he believed the Corporation would be willing to pay 1s. per ton to have it removed.

The **Chairman** said the use of the refuse depended upon the amount of steam it evaporated. Mr. Parsons would no doubt be glad to consider any suggestion in the matter.

Mr. Parsons said it had been tried, and it was found that only a ton of water was evaporated per ton of refuse in most cases.

The report was adopted, and the alterations in the rules, rendered necessary to allow the shares to be quoted, were carried.

LIVERPOOL OVERHEAD RAILWAY COMPANY, LIMITED.

The eleventh ordinary half-yearly meeting of the shareholders of this Company was held in Liverpool on Tuesday, Sir W. B. Forwood presiding.

The **Chairman**, in proposing the adoption of the report, which was published in our issue of the 2nd inst., said that the report was of the first complete half-year of the Company down to December 31 last. The gross earnings for the six months amounted to £18,518. 4s. 7d., to which must be added £3,293 balance brought forward, making the total available sum £21,811. 11s. 2d. Deducting from this working expenses for the half-year £13,732. 11s. 2d., interest on debentures, and also interest on calls paid in advance, they had left over the sum of £5,452 available for dividend. Out of this the directors proposed to pay a dividend at the rate of 5 per cent. on the preference shares, and at the rate of 1 per cent. on the ordinary shares, which would leave a balance of £2,598. 7s. 1d. to be carried forward to the next half-year. The directors were well satisfied under all the circumstances with the result, for during the greater part of the half-year the trade of the port was most depressed, and the dock omnibuses obtained a considerable measure of support. The total number of passengers carried reached 2,475,639, or, roundly, at the rate of five millions per annum. The dock omnibuses are probably carrying at the rate of 2,500,000 per annum, so that they have a total traffic of about 7,500,000 against 2,300,000, the number carried by the dock 'buses before the railway was opened. Thus, during the first year of the railway's existence the dock traffic had increased threefold, which in itself was a most encouraging feature. Every day the regularity and convenience of this railway forced itself more and more upon the public attention and public support. The cost of working came out at over 72 per cent of the receipts, which looked large as compared with the experience on ordinary English railways, but this test was a fallacious one. If their fares were equal to those charged on ordinary English railways, their income would be very much larger, and the ratio of expenses greatly reduced. A better test is to compare their cost of working with the South London Electrical Railway. Their cost worked out 1s. 0½d. per mile, and the South London 1s. 0⅜d. per mile. They hoped still to make further economies. The extension to Seaforth would be opened in March. He had never wavered in his opinion that they had a good property. Mechanically it had been a great success, and financially it would also be a success.

Mr. R. Hobson, in seconding, expressed his sanguine feelings in regard to the future of the railway.

The report was then adopted.

The **Chairman** next proposed the payment of dividends at the rate of 5 per cent. per annum on preference shares, and 1 per cent. per annum on ordinary shares, less income tax, and that the balance on the net revenue account be carried forward. He hoped that this resolution was the forerunner of many of a still more gratifying character.

Mr. G. H. Robertson seconded the motion, which was carried. The re-election of directors and auditors closed the proceedings.

CENTRAL LONDON RAILWAY COMPANY.

A special general meeting of the Central London Railway Company was held last week at 30, St. Swithin's-lane, for the purpose of submitting to the proprietors a proposed Bill in Parliament, entitled "A Bill to extend the time for the purchase of lands for and for the completion of the Central London Railway and for other purposes."

Mr. F. A. Lucas, who presided, moved a formal resolution approving the Bill, this being seconded by **Mr. H. Smith**.

Mr. W. Morris (the solicitor) said the object of the Bill was to extend the time for the purchase of lands and the completion of works under the two Acts of the Central London Railway Company. The Bill now under consideration provided that the time for purchasing land in respect of the whole undertaking should be extended until 1897, and for completing the whole of the works until 1900. It had been suggested that, in consequence of a paragraph that by inadvertence appeared in a newspaper some time ago, he should state that there was nothing whatever in the Bill to alter the mode of traction intended to be adopted on the railway. The only traction authorised was electricity, and it was intended to adhere to that.

The Bill was approved.

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INDIA RUBBER, GUTTA PERCHA, AND TELEGRAPH WORKS, LIMITED.

The thirtieth ordinary general meeting of the shareholders of this Company was held at Cannon-street Hotel yesterday (Thursday) to receive the report of the directors, which we printed in our last issue.

Mr. S. Wm. Silver (the chairman), in moving the adoption of the report and accounts, stated that at the last meeting he had held out favourable prospects. The colliery difficulties had, however, exercised some effect upon the working expenses; but their steamer which had been laying a cable on the West Coast of South America had brought back with her several hundred tons of coal which had been utilised at the works. For coal to be brought to England from South America, and thus employed, was rather a remarkable occurrence. The coal strike had also had the effect of stopping mills, and thereby reducing the quantity of material required for engineering purposes. They did not look upon general sales as a sheet anchor, for these had been a main means of support, as little had been done in cable work. They had, however, supplied the city of Brussels with the electric light. All this meant that more capital was required, the money being invested in work, stock, etc. The directors therefore recommended that a sum of £50,000 be added to the reserve fund. The stagnation of trade had enhanced competition and increased the difficulty of doing good business. There was plenty of business to be done, but it was difficult to find that which would be profitable. However, great care and caution had been exercised in this matter. The Chairman concluded by moving the adoption of the report.

Mr. Abraham Scott seconded this motion.

Mr. Lamont requested information respecting the reserve fund of £450,000, asking whether it could be dipped into in a bad year to pay debenture interest and something extra for ordinary shareholders, and whether it was invested in safe tangible securities at once realisable. Another **Shareholder**, referring to the item of £207,000 of debentures and shares held in other companies, did not think it advisable that one company should hold shares in another.

The **Chairman** explained that the reserve fund was capital employed, without interest, in lands, buildings, and machinery, and without this reserve there would be little to fall back upon as an industrial concern, and the result would be that instead of a dividend of 12½ per cent. there might only be 1½ per cent. The value of the reserve fund could be realised, and the item of £207,000 represented present value which could also be realised.

The **Chairman** moved the re-election, as directors, of Mr. Abraham Scott and Mr. Robert Henderson.

This was seconded by the **Hon. Henry Marsham** and adopted unanimously.

Mr. J. F. Clarke was reappointed auditor at a fee of 30 guineas.

Mr. Matthew Gray, the managing director, mentioned that he had visited Brussels and found that their work on the electric lighting of that city was very well done. He had also gone to their French works at Persan, which were in first-class order, and were fully employed. The Silvertown works were also fully employed.

CUBA SUBMARINE TELEGRAPH COMPANY.

The forty-fifth ordinary meeting of the Cuba Submarine Telegraph Company, Limited, was held on Wednesday at 58, Old Broad-street, under the presidency of Mr. Thomas Greenwood.

In moving the adoption of the report, the **Chairman** said the directors were pleased to be able to present so satisfactory a report. The depression in trade, which had so materially affected such a large number of industrial undertakings, had had some influence upon the receipts of the Company. Comparing the traffic receipts of the past half-year with those of the corresponding period of 1892, there appeared to be a reduction of £1,122. This was not due in any sense to the reduction of rates, which had not yet been made, but to the exigencies of trade. The net receipts for the half-year were only £787 less than in the corresponding period.

Mr. Charles W. Parish seconded the motion, which was carried unanimously. Dividends at the rate of 10 per cent. per annum on the preference shares and 8 per cent. on the ordinary were declared.

COMPANIES' REPORTS.

CITY OF LONDON ELECTRIC LIGHTING COMPANY, LIMITED.

Directors: Sir David L. Salomons, Bart., chairman; the Earl of Suffolk and Berkshire; the Hon. Alan Charteris; Joseph Bevan Braithwaite, jun.; Edward Lucas; Colonel B. H. Martindale, C.B.; Frederick W. Reynolds. David Cooke, engineer and manager. J. Cecil Bull, secretary.

Report of the directors to be presented to the shareholders at the ordinary general meeting of the Company to be held at Winchester House, Old Broad-street, E.C., on Thursday, February 22, 1894, at 2.30 p.m.

Capital.—The expenditure on capital account during the year ended December 31, 1893, amounted to £260,757. 18s. 1d. Details of this further outlay are given in the capital account, the whole of which is rapidly becoming revenue-earning. During the year the remainder of the preference shares have been issued, and all are now fully paid-up. An official quotation for the second issue of £200,000 has been applied for, and will no doubt be shortly granted. In order to provide for the additional expenditure which will be necessary to complete the undertaking, the directors propose to issue debenture stock from time to time as required. A first issue to the extent of £100,000 will be made immediately, and applications received from the holders of the ordinary and preference shares of the Company will be preferentially considered.

Revenue.

The gross revenue for the year was					£38,556	10 3
From which must be deducted the following items charged against revenue:						
Expenses of generation and distribution	£18,374	14	8			
Repairs and maintenance of plant, machinery, mains, lamp-posts, etc.	2,285	18	4			
	20,660	13	0			
Rents, rates, taxes, and general charges were	2,431	0	8			
					23,091	13 8
Leaving a net revenue of					15,464	16 7
To which must be added, other receipts					1,475	18 3
,, ,, ,, balance brought forward from 1892					434	6 7
Making a total of					£17,375	1 5

Of this sum £5,333. 6s. 8d. was distributed in July last in payment of an interim dividend on the first issue of £200,000 preference shares at the rate of 6 per cent. per annum for the half-year ended June 30, 1893, and the directors recommend a further dividend of 6s. per share on the first issue of £200,000 and of 3s. per share on the second issue of £200,000 preference shares, both payments being at the rate of 6 per cent. per annum for the half-year ended December 31, 1893. This will absorb £9,000, leaving a balance of £3,041. 14s. 9d., which the directors propose to carry forward to next account. After careful consideration, the directors have decided to establish two depreciation reserve funds, the first (Nos. 1 and 1A in the accounts) for the plant and running machinery, engines, boilers, dynamos, etc., and the second (No. 2 in the accounts) for the mains, meters, transformers, and other items from Nos. 2 to 10 in the capital account. For this purpose, out of the premium of £40,000 received from the second issue of preference shares, £30,000 has been set aside for the first fund and £9,152. 19s. 3d. for the second. Owing to the delay on the part of the local authority in giving its consent, as required by the Telegraph Act, 1892, to the use of certain tubes for telephonic purposes, the further steps necessary could not be proceeded with, and therefore it has not been possible to include in the accounts the sums payable by the New Telephone Company, Limited, under the agreement. Negotiations are, however, still proceeding, and it is hoped that the consent of the local authority will shortly be given. The working expenses for the year, including repairs and renewals, were 54·2 per cent. of the earnings. In view of the exceptionally fine and bright weather, which adversely affected the receipts, and the prolonged coal strike, which seriously increased the expenses, the directors consider this result satisfactory. The revenue shows a steady increase, the estimated rate at which it is now being earned being £64,000 per annum gross. This it is hoped will be largely increased as soon as the remaining transformer stations are at work. The directors were successful in obtaining an Act of Parliament amalgamating the three City districts into one for the purposes of the accounts and for defining in a clearer manner certain other matters in connection with the Company's provisional orders.

Lands and Buildings.—The greater portion of the main buildings is now practically finished and the remainder is expected to be completed in March next. The pumping station, switch-rooms, and engineer's offices are also in a forward state. Twenty-two transformer stations have been constructed, of which eight are in operation, and every effort is being made to have all the others ready for work during the current half-year. These 22 stations, when fully equipped, will be equal to supplying at least 400,000 8-c.p. lamps installed.

Generating Plant.—The plant already in position is of a capacity of 100,000 8-c.p. lamps, and further machinery is in course of construction by the contractors. The arc lighting plant has worked satisfactorily throughout the year. The total number of units sold was 1,741,099.

Street Work.—This work is now approaching completion. On the 1st February, 1894, 580 miles of "ways" had been laid in the City in 55½ miles of streets, into which 105 miles of cables have been drawn. Sufficient "ways" have been laid down to supply a demand of 400,000 8-c.p lamps installed. Conduits have been laid in all the compulsory streets in the Southwark district.

Private Lighting.—Nearly 1,300 private consumers, representing a total of 72,000 8-c.p. lamps, are being supplied with current from eight transformer stations, and during the current half-year it is expected that the whole 22 stations required for the entire City will be at work. Applications continue to come in satisfactorily, the total received to date being equal to the supply of current for 100,000 8 c.p. lamps.

Public Lighting.—The lighting of the main thoroughfares of the City with arc lamps was virtually completed early last year, only a few lamps for which positions have not been assigned remaining to be fixed, but the Commissioners of Sewers have not yet given

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the order for the lighting of the lesser streets with incandescent lamps. The Company is prepared to carry out the lighting of these streets immediately upon receipt of the order to proceed, the necessary plant for this purpose being already in position.

Directors.—In accordance with the articles of association, two of the directors, Sir David L. Salomons, Baronet, and the Hon. Alan Charteris, retire. Sir David L. Salomons, being eligible, offers himself for re-election, but Mr. Charteris, owing to continued ill-health, resigns his seat. The directors do not recommend that any steps be taken at present to fill the vacancy thus created.

Auditors—Messrs. W. H. Pannell and Co. retire, and, being eligible, offer themselves for re-election.

Dr. CAPITAL ACCOUNT AT DEC. 31, 1893.

Expenditure.	Public lighting. £ s. d.	Private lighting. £ s. d.
Machinery and plant: boilers, pumping, feed-heating appliances, engines, arc dynamos, alternators, and exciters	32,196 13 4	145,452 10 0
Mains (including cost of laying and repaving)	38,459 5 8	169,439 10 2
Transformers and accessories	—	33,203 4 9
Meters and electrical instruments	95 9 11	7,237 19 9
Lamp-posts, lanterns, lamps, and accessories	24,382 10 8	—
Tools and plant	977 10 7	1,642 17 5
Cost of obtaining three provisional orders under agreements with contractors, and expenses in connection with "1893" Act	3,277 3 9	3,277 3 9
Office furniture	189 18 9	569 16 4
Proportion of management and general expenses chargeable to capital—rents, rates, and taxes, salaries, directors' fees, remuneration of late chief engineer, professional charges, etc.	6,116 14 3	18,350 2 10
	105,695 6 11	379,173 5 0
Total of public and private lighting		484,868 11 11
Buildings		71,231 3 0
Freehold land, including law charges incidental to acquisition		75,342 6 9
Southwark lighting—		
Cost of obtaining provisional order, expenditure on mains, etc.		8,592 11 1
Total for electric lighting purposes		640,034 12 9
Expenditure on conduits for telephonic purposes		68,886 18 1
Total carried to balance-sheet		708,921 10 10
Balance of capital account		90,688 9 2
		£799,610 0 0

Cr. Receipts.	£ s. d.
40,000 ordinary shares of £10 each	400,000 0 0
40,000 6 per cent. preference shares of £10 each, £400,000—less instalments outstanding—£390	399,610 0 0
	£799,610 0 0

REVENUE ACCOUNT FOR 12 MONTHS ENDED DEC. 31, 1893.

Dr.	Public lighting. £ s. d.	Private lighting. £ s. d.
Generation of electricity—		
Coal and other fuel, including dues, carriage, unloading, storing, and all expenses of placing the same on the works	3,612 12 3	5,414 12 9
Oil, waste, and engine-room stores	350 5 0	428 15 0
Water	270 11 9	390 15 3
Salaries of station engineers and assistants	447 9 11	671 4 9
Wages and gratuities at generating stations	1,490 12 9	1,632 11 2
Repairs and maintenance as follow:		
Buildings	10 16 3	52 14 5
Boilers, heaters, etc.	189 13 1	177 14 5
Engines and condensers	310 13 10	425 6 4
Dynamos and exciters	168 4 11	229 18 7
Other machinery, instruments, and tools	117 4 8	103 3 1
Total generation expenses	6,967 4 5	9,526 15 9
Distribution of electricity—		
Proportion of salaries of officers, as certified by the engineer and manager and approved by Board	200 0 0	150 0 0
Wages and gratuities to linesmen, fitters, and trimmers of street lamps	1,175 6 3	—
Wages and gratuities to transformermen	—	632 11 5
Repairs, maintenance, and renewals of mains, lamp-posts, and transformers	491 19	8 9 5
Carbons and other materials for street lamps	1,508 6 5	—
Total for generation and distribution	10,342 16 5	10,317 16 7
Proportion of rents, rates and taxes—		
Rents payable	253 2 11	379 14 5
Rates, taxes and lighting	74 16 0	112 3 11
Proportion of management expenses—		
Directors' remuneration, salaries of secretary, accountant, clerks, and messengers, as certified by the engineer and manager, and approved by Board	370 13 5	556 0 1
Printing and stationery	35 12 8	53 8 11
General establishment charges	22 12 8	33 19 0
Auditors' fees	10 0 0	15 0 0
Special charges—		
Allowances, deductions, and bad debts	104 1 1	265 9 8
Insurances	57 14 4	86 11 7
Total expenditure	11,271 9 6	11,820 4 2
Total for public and private lighting		23,091 13 8
Balance, being revenue for period carried to net revenue account		15,464 16 7
		£38,556 10 3

Cr.	Public lighting. £ s. d.	Private lighting. £ s. d.
Sale of current	—	25,210 9 11
Revenue under contracts	11,946 12 3	—
Meter rentals	—	967 9 1
Transfer fees	48 7 7	72 11 5
Rents receivable	99 12 5	149 8 7
Testing fees	—	61 19 0
Total receipts	12,094 12 3	26,461 18 6
Total of public and private lighting		£38,556 10 3

Dr. NET REVENUE ACCOUNT.	£ s. d.
Balance as per general balance-sheet	17,375 1 5
	£17,375 1 5

Cr.	£ s. d.
Balance from last account:	
Profit of private lighting (1892)	1,141 4 8
Less loss on public lighting (1892)	706 18 1
	434 6 7
Balance from revenue account to December 31, 1893	15,464 16 7
Interest on deposits, investments, etc.	1,475 18 3
	£17,375 1 5

GENERAL BALANCE-SHEET AS AT DEC. 31, 1893.

Dr. Liabilities.		£ s. d.
Capital account		799,610 0 0
Sundry tradesmen and others, due on construction of plant, machinery, fuel, stores, etc.		15,074 2 5
Sundry creditors on open accounts		4,439 1 9
Premiums on preference shares appropriated to depreciation reserve fund, No. 1	£2,158 1 1	
Do. do. No. 1A	27,841 18 11	
Do. do. No. 2	9,152 19 3	
Reserve fund	847 0 9	
		40,000 0 0
Net revenue account—Balance at credit thereof	17,375 1 5	
Less interim dividend on £200,000 preference shares (first issue) to June 30, 1893	5,333 6 8	
Balance available for distribution as proposed in report		12,041 14 9
		£871,164 18 11

Note.—Under existing contracts relating to the equipment of the stations and other works, there are contingent liabilities which become due only after completion and final acceptance of the work.

Cr. Assets.		£ s. d.
Capital expenditure		708,921 10 10
Stores on hand		14,429 18 10
Sundry amounts paid on account of building contracts in course of completion		12,550 0 0
Expenses of issue of ordinary and preference shares*	12,030 18 6	
Less written off	1,564 10 0	
Balance to be written off out of revenue in subsequent years		10,466 8 6
Sundry debtors for current supplied		19,030 13 2
Other debtors		12,518 13 8
Cash at bankers on deposit and current accounts		45,982 12 0
Sundry deposits under provisional orders, etc., and interest accrued thereon		7,265 1 11
Investments—depreciation and reserve funds invested in 2¾ per cent. consols		40,000 0 0
		£871,164 18 11

* Total capital issued and premiums received, £840,000. The expenses of issue are therefore less than 1½ per cent.

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WESTMINSTER ELECTRIC SUPPLY CORPORATION, LIMITED.

Directors: The Right Hon. Lord Suffield, K.C.B.; Edmund Boulnois, Esq., M.P.; W. Hayes Fisher, Esq., M.P.; Sir Douglas Galton, K.C.B., F.R.S.; J. Browne Martin, Esq.; James Heslop Powell, Esq.; R. W. Wallace, Esq. General manager: Captain Edmund I. Bax. Engineer-in-chief: Prof. Alex. B. W. Kennedy, F.R.S., M.I.C.E. Secretary: Frank Iago, Esq.

Report of the directors to be presented to the shareholders at the ordinary general meeting to be held at the offices of the Corporation, Eccleston-place, S.W., on Wednesday, February 21, 1894, at 11 a.m.

The Board of Directors, in presenting their report and accounts for the year 1893, are pleased to state that the business of the Corporation continues to make steady and satisfactory progress. The directors have again thought it desirable to reduce the price of current from 7d. to 6d. per unit, and this change came into effect on April 1 last. The supply of current which on December 31, 1892, was being provided for an equivalent of 98,686 lamps of 8 c.p., had increased by December 31, 1893, to the equivalent of 131,565, and at the present time there are on circuit the equivalent of 134,268 lamps of 8 c.p., and applications have been received for a further 9,451. The length of roadway along which mains have been laid now exceeds 35 miles, making about 140 miles of ways, into which upwards of 106 miles of copper (strip and cable) have been drawn. The plant and machinery have been working satisfactorily throughout the year, and have been fully maintained from revenue. In the manufacture and distribution of electricity and in the general expenses a considerable reduction has been effected in the cost per unit. Since the last meeting, owing to the rapid increase in the Corporation's business, the directors found it necessary to issue the balance of £30,000 4½ per cent. mortgage debentures. The issue having been largely over subscribed by the shareholders, the directors regretted they were unable to allot in full. The net revenue of the year amounts to £12,830, out of which £4,370 in payment of an interim dividend at the rate of 3 per cent. per annum for the half-year ending June 30, 1893, has already been distributed. The accounts now show a balance of £8,460 to the credit of net revenue, from which the Board recommend the payment of a dividend at the rate of 5 per cent. per annum for the half-year ending December 31 last, carrying forward a sum of £1,190. In accordance with the articles of association, two of the directors, Lord Suffield and Mr. Hayes Fisher, retire, but being eligible, offer themselves for re-election. The auditors, Messrs. Cooper Bros., also retire.

Revenue Account, Year ending Dec. 31, 1893.

Dr.	£ s. d.	£ s. d.
A.—To Generation of Electricity.		
Coal, carriage unloading, etc.	5,555 11 10	
Oil, waste, water, and engine-room stores	1,401 3 4	
Proportion of salaries of engineers and officers	1,505 0 0	
Wages, etc., at generating stations	4,421 16 4	
Repairs and maintenance—buildings, £87. 0s. 10d.; plant, £1,648. 11s. 2d.; repairs of instruments, £8. 19s. 3d.	1,744 11 3	
		14,628 2 9
B.—To Distribution of Electricity.		
Repairs and maintenance of mains	£503 2 9	
Proportion of salaries of officers	150 0 0	
Wages, etc.	688 14 5	
	1,341 17 2	
Repairs and maintenance of meters	20 17 1	
Wages, etc.	232 4 3	
	253 1 4	
		1,594 18 6
C.—To Rents, Rates, and Taxes.		
Rents	918 11 10	
Rates and taxes	2,128 6 0	
		3,046 17 10
D.—To Management Expenses.		
Directors' fees	800 0 0	
Salaries of manager, engineer-in-chief, secretary, clerks, etc.	3,106 16 9	
Stationery and printing	252 4 7	
General charges and office expenses	517 14 3	
Auditors of Company	52 10 0	
Wages of meter readers, inspectors, etc.	759 6 10	
Depreciation on office furniture	63 0 0	
		5,551 12 5
E.—To Law and Parliamentary Charges.		
General law charges		275 18 8
F.—To Depreciation.		
Sinking fund on buildings and leases	400 0 0	
Depreciation of plant and machinery	2,500 0 0	
		2,900 0 0
G.—To Special Charges.		
Insurance	207 1 2	
Board of Trade audit	62 14 0	
		269 15 2
Total expenditure		28,267 5 4
Balance to net revenue account		15,565 11 3
		£43,832 16 7

Cr.	£ s. d.
Sale of current by meter	40,860 4 8
,, ,, contract	1,309 11 0
	42,169 15 8
Less bad and doubtful debts	220 10 10
	41,949 4 10
Rental of meters on consumers' premises	1,847 14 3
Transfer fees	35 17 6
	£43,832 16 7

Dr. Net Revenue Account.

	£ s. d.
Interest on mortgage debentures, etc., £3,700. 6s. 6d., less income tax	3,599 6 0
Amount written off preliminary expenses account	1,000 0 0
Amount written off patents and law charges account	216 0 0
Balance carried to general balance-sheet	12,830 17 2
	£17,646 3 2

Cr.	£ s. d.
Balance from last account	7,324 8 9
Less half-year's dividend to December 31, 1892, at 4 per cent. per annum, £5,990, less income tax	5,840 4 2
	1,484 4 5
Balance from revenue account	15,565 11 3
Interest on temporary deposits	20 5 11
Rents paid and accrued	576 1 5
	£17,646 3 2

Dr. General Balance-sheet, Dec. 31, 1893.

	£ s. d.	£ s. d.
Capital account		400,000 0 0
Sundry creditors		3,213 0 3
Debenture interest accrued		1,600 5 5
Depreciation account		6,136 0 0
Sinking fund account		1,236 0 0
Net revenue account	£12,830 17 2	
Less interim dividend to June 30, 1893, at 3 per cent. per annum, £4,492. 10s., less income tax	4,370 12 3	
		8,460 4 11
		£420,645 10 7

Cr.	£ s. d.
Capital account	381,276 9 10
Stores in hand	495 0 3
Sundry debtors	15,771 3 7
Cash on deposit	10,000 0 0
Cash at bankers—Messrs. Barclay, Ransom, and Co.	3,706 13 4
Preliminary expenses and suspense account	8,450 2 7
Less amount written off for 1893	1,000 0 0
	7,450 2 7
Patents and law charges account	2,162 1 0
Less amount written off for 1893	216 0 0
	1,946 1 0
	£420,645 10 7

Statement of Electricity Generated, Sold, etc., Year ending Dec. 31, 1893.

Board of Trade units generated		1,999,383
Quantity utilised:		
Sold to consumers	1,704,615	1,743,232
Used on works for lighting, meter-testing, etc.	38,617	
Quantity expended in distribution:		
In batteries	21,082	230,517
In feeders	209,435	
Total quantity accounted for		1,973,749
Quantity unaccounted for		25,634
Number of 8-c.p. lamps on circuit, December 31, 1893.		131,565

BUSINESS NOTES.

Western and Brazilian Telegraph Company.—The receipts for the week ended February 9 were £3,007.

Liverpool Overhead Railway.—The traffic receipts of this railway for the week ending 11th inst. amounted to £691.

Aluminium Company.—An extraordinary general meeting of the Aluminium Company, Limited, was held on Wednesday at the Cannon street Hotel, E.C., to alter article of association 92.

Margam.—The Lighting Committee of the Local Board have recommended that the district should be lit by electricity, and that a report be obtained from Messrs. Drake and Gorham on the matter.

Babcock and Wilcox Company.—An interim dividend has been declared for the six months ending December 31, 1893, at the rates per annum of 6 per cent. on preference shares and 10 per cent. on ordinary shares.

Tender Accepted.—The tender of Messrs. S. J. Waring and Sons, at £320, has been accepted for electric wiring and ventilation at the Hamilton Café, Chapel-street, Liverpool, for the Clerks' Café Company, Limited.

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Abergavenny.—The Improvement Committee have resolved that the Gas Committee be empowered to call in the services of an expert in the matter of lighting Abergavenny by electricity.

Mosley and Co., Limited.—This Company has been registered with a capital of £11,000 in £1 shares to acquire patents relating to the deposition by electricity of zinc upon steel, iron, or other metals, and to develop the same.

Bradford.—On the electricity works the Corporation have made a profit of £1,179 during the past half-year, as against £1,089 for the previous half-year, despite the fact that they had had to pay £600 extra on account of the coal strike.

Brush Electrical Engineering Company.—The transfer books of the Brush Electrical Engineering Company, Limited, will be closed, both for debenture stock and preference and ordinary shares, from February 20 to March 5 inclusive.

Horsell (Surrey).—The tender of Mr. H. Ingram has been accepted for the erection of a bungalow in the parish of Horsell, for Mr. J. B. S. Lancaster, to be heated entirely with gas, and lighted by electricity. Mr. R. Clamp, A.R.I.B.A., Woking, is the architect.

Liverpool.—The Watch Committee of the Liverpool Corporation have received a letter from Mr. Davies calling attention to his system for the utilisation of tidal power for electric lighting purposes. The letter was referred to the electric lighting company.

Appointments Vacant.—As mentioned in our last issue, the Blackpool Corporation require a resident working electrical engineer for the tramways. The Corporation of Edinburgh invite applications for the post of resident engineer for central electric lighting station.

Leamington.—Through the kindness of a member of the congregation in advancing the amount of the initial cost, the electric light is now installed at the parish church. Nearly 300 lamps have been fixed. From the central dome depends a large and ornamental electrolier.

Newcastle.—A special committee of the Town Council relative to the Corporation undertaking the provision of electricity, has been held. It was decided to communicate with other towns where the corporations have sole charge of the electric lighting, and obtain particulars regarding the same.

Sutton.—It was reported at a meeting last week of the Local Board that the proposed deed of transfer regarding the electric light had been revised by the clerk, so as to include the latest suggestions of the Board of Trade. The draft was referred back to the committee for further consideration.

City and South London Railway.—The receipts of the Company for the week ending February 11 were £937, against £952 for the same period last year, or a decrease of £15. The total receipts for the first half-year of 1894 show a decrease of £135 compared with those for the corresponding period of 1893.

Oswestry.—Mr. Lloyd mentioned at a meeting of the Town Council last week that he would be glad if they could come to some terms with the electric lighting company. The company had informed them that they were ready to commence operations, and it was their duty to see that the town was well lighted.

Limehouse.—At a meeting of the District Board of Works last week, Mr. Beverley enquired if the special committee appointed to consider the proposed lighting of the district by electricity intended to report to the Board. In reply, Mr. Mills explained that the report had been drafted, but that its presentation was delayed.

Appointment.—Mr. Le Gros Horne, of the Electric Light Department, General Post Office, has been appointed to the post of Superintendent of Telegraphs and Electric Light to the Great North of Scotland Railway Company. The electric light is a new post added to that of the telegraph work, and extensive additions of plant will be made.

Burton.—At a meeting of the Town Council last week, Alderman Lowe announced that supply of the electric light would be ready during the present month. He stated that if the Corporation did not receive a great many more applications for its use—they had only had 20—they would lose considerably over the introduction of the new illuminant.

Portsmouth.—The Electric Light Committee of the Town Council last week submitted certificates from Messrs. Waller and Manville for payment to the contractor for buildings of £225, to the contractors for boilers, engines, and electrical plant £1,609, and to the contractors for conduits, etc., £1,840, and recommended that such amounts be paid. The report was adopted.

Paisley.—The Cartvale Chemical Company at the beginning of the winter decided to adopt the electric light, and entrusted to Messrs. Robertson and Co., electrical engineers, 9, Old Sneddon, the work of installation. This is now completed, and the works are lighted with seven arc lamps of 2,000 c.p. A 12-h.p. steam-engine drives a Woodside dynamo, which supplies the lamps.

Bridgend (Glamorganshire).—The Local Board are prepared to receive tenders for the transfer of the provisional order for electric lighting obtained by the Board in June, 1893, on the basis of the payment to the Board of the costs of and incidental to the obtaining of the order, and which amount to about £250. Further particulars may be had of Mr. T. J. Hughes, solicitor, clerk to the Board.

Swansea.—The Executive Committee of the Harbour Trust have had under consideration a report by the general superintendent upon the subject of the electric light wires, and they recommended that certain bare wires should be replaced by insulated wires, and accordingly that they be authorised to invite tenders for and arrange to carry out the work. The recommendation has been adopted.

Ballymena (Ireland).—As stated in our last issue, tenders are invited by the 3rd proximo for lighting the town either by gas or electricity, from August 16, 1894, until May 16, 1895, for the Town Commissioners. Plans, time-table, and specification to be seen at the office of Mr. Henry O'Hara, town clerk, Town Hall-chambers, Ballymena. Sealed tenders to be lodged with the town clerk by the date mentioned.

Radcliffe.—Mr. Bennett and Mr. Preece have met the Electric Lighting Committee to confer with them as to the preparation of the report of the proposed electric lighting of the district. Each has been instructed to prepare a report upon the most advisable method of producing and distributing electricity within the limits of the district, giving estimates of the cost of production and maintenance by both Dowson gas and steam.

Belfast.—The report of the Harbour Commissioners for 1893 contains the following: "A contract for the execution of certain works in connection with the lighting by electricity of the Queen's Quay and Abercorn Basin was entrusted to Messrs. Siemens Bros. and Co., Limited, who supplied the engine and boiler (which were manufactured by Messrs. Combe, Barbour, and Combe, Limited), and the electrical plant, comprising two dynamos and 30 arc lamps, with all requisite pillars and cables. The foregoing works were carried out under the supervision of Mr. George Combe, electrical engineer, of this city."

Electric Lighting in Stirling.—The Board of Trade have sustained an objection to the decision of the Stirling Town Council refusing to consent to the application of the Caledonian Electric Supply Company for a provisional order for Stirling, in respect that the statutory 30 days' notice was not given of the Council's intention to apply for a provisional order themselves. The effect of this ruling is to render it necessary to begin the proceedings again, and notices are to be issued of a special meeting of the Town Council in March for the purpose of determining whether the Corporation shall apply for a provisional order.

Accrington.—The Watch and Cemetery Committee of the Town Council have considered tenders for putting in an installation of electric bells to each fireman's house from the fire brigade station. The tenders varied in amount from £48. 6s. to £85. It was resolved that the chairman and town clerk make enquiries as to the character of similar work done by the firm submitting the lowest tender, and report to the next meeting. The Legal and Parliamentary Committee have considered the question of pushing forward with the electric light installation, and have instructed the Mayor, Alderman Moorby, and Councillor Eli Higham, with the surveyor, to visit the electric lighting works at Morecambe and report thereon.

Blackpool.—At a meeting of the Town Council last week, Mr. Councillor Bickerstaffe asked for an explanation of certain transactions with Messrs. John Fowler and Co., in regard to the tramways. Mr. Councillor Pearson said that at the outset it was decided to procure two new engines to drive the electric tramways, and arrangements were made with Messrs. John Fowler and Co. whereby they should take over the two old ones and erect new engines for the sum of £120. They had since received reports from their advisers that with very few alterations the engines would do the work, and they were now endeavouring to get Messrs. Fowler and Co. to release them from their reliability in regard to these engines.

Darwen.—The Corporation of Darwen have accepted the tender of Mr. Thomas Barton, the Electrical Works, Blackburn, for a complete generating and distributing electrical plant, to be utilised at present for the new technical schools, but which is intended to form a nucleus for the lighting of the town. The plant consists of dynamos and switch and distributing boards, made by Mr. Barton; installation cables, manufactured by Messrs. Siemens Bros. and Co.; storage cells, made by the Electrical Power Storage Company; and gas-engine, by Messrs. J. E. H. Andrew and Co. The plant has been erected upon the same lines as that in the Blackburn technical schools and other public institutions carried out by Mr. Barton.

Lighting of Chelmsford.—A meeting of the Town Council was held last week to consider Messrs. Crompton and Co.'s application to the Board of Trade for a provisional order to supply electric energy for the public and private lighting of Chelmsford. The Mayor urged that they should settle the whole question that evening. Councillor Britton moved that the minute passed by the Council on December 27 be rescinded as far as it related to Clause 80 of the provisional order, and that they should accept the terms of the provisional order as modified by the solicitors for the company. Councillor Maskell seconded the motion, which, after some discussion, was carried. A further resolution, that the consent of the Council be given to the amended provisional order, was also adopted.

Lighting of Halifax.—The following tenders for the supply of electric lighting plant have been accepted by the Halifax Corporation: Messrs. Pollitt and Wigzell, Sowerby Bridge, three non-condensing steam-engines, £1,860; Messrs. Yates and Thorn, Blackburn, three steel Lancashire boilers, £1,688, also fuel economiser, with brickwork, £489; Electric Construction Company, Limited, Wolverhampton, alternators, £1,785, and exciters, £270; Messrs. John Fowler and Co., Leeds, switchboard, £460; Messrs. C. A. Parsons and Co., Newcastle, transformers, £844. 6s.; Messrs. Siemens Bros. and Co, Limited, Westminster, supplying and laying underground cables, etc., £7,450; Mr. Thomas Mitchell, of Warley, for masons' work, £5,200. 6s. 8d.; and Mr. James

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Mackrell, of Elland, wrought-iron work, £841, work required in the erection of the central electric lighting station.

Dover.—The minutes of the Electric Light Sub-Committee, read at a meeting of the Town Council last week, stated that the installation of the Town Hall had been under consideration, and that plans and estimates had been received from the Dover Electricity Company, and Mr. Chappel consulted as to the lights. The estimates were—for the new Town Hall, wires £308, fittings £264. 12s., total £572. 12s ; Maison Dieu Hall, wires £180, fittings £150, total £330. The committee recommended that the tender for the Connaught Hall only should be approved. Alderman Pepper, in moving the adoption of the report, said that the estimates were higher than expected. He moved that the committee's recommendations be accepted, and Councillor Barnes seconded the motion, which, after some discussion, was adopted.

York.—The question of electric light expenses at the Courts of Justice was referred to last week by Mr. Walker, who said that there was an item of £19. 10s. 7d. for lamps for electric light for one quarter at the Courts of Justice. Was that for repairs, breakages, or what? He also noticed that the gas used for the gas-engine to produce electricity for the September quarter was £27. 4s. 8d., whilst the wages for working the gas-engine amounted to £33. 4s. for one quarter, the items amounting altogether to about £75. They had, therefore, a right to assume that the gas accounts for the quarters of March and December, when the days were longest, would be about double. He estimated that the electric light for the Courts of Justice would cost them for gas, engine, and man, exclusive of other charges, something like £270 or £280 per year. Alderman Milward said that he had better have notice of the question.

Lighting of the Victoria-embankment.—The Highways Committee of the London County Council on Tuesday reported that the drawings for the installation works for the lighting of the Victoria-embankment and gardens, and Westminster and Waterloo Bridges, are in course of preparation, and will shortly be so far completed that the specification and estimates may be prepared. In the meantime it appeared to them that the work of laying the necessary conduits and forming the refuges round the lamp columns could be proceeded with at once. The chief engineer's estimate of the cost of this preliminary work is £2,100, and the committee recommended that, subject to an estimate being submitted to the Council by the Finance Committee, as required by the statute, the work of laying the necessary conduits and the forming of the refuges round the lamp columns in connection with the electric light installation for the Victoria-embankment, etc., be carried out by the Council without the intervention of a contractor; and that the plans, specification, and estimate be referred to the Works Committee for that purpose. This matter was referred back to the committee.

Lighting at Colchester.—The Lighting Committee of the Town Council reported last week that they had considered the steps to be taken for carrying out the provisions of the Colchester electric lighting order, which was confirmed by Parliament on June 9, 1893. The committee concluded that it would be better, in the first instance, to have a preliminary interview with an electrical engineer, and decided to invite Mr. W. H. Massey to meet them. Mr. Massey attended a meeting of the committee on January 29, when the whole question was fully discussed, and his opinion invited on various points. Mr. Massey stated, having in view the fact that the electric lighting works would probably be carried on in conjunction with other undertakings of the Corporation, and the low rate of interest at which the authority could borrow, the Council would be able to undertake the supply of electricity, and make the undertaking pay its way. Several sites which the committee considered might be suitable for the purposes of a lighting station were inspected. The committee had instructed Mr. Massey to report fully upon the points above mentioned. The report was adopted.

Tenders Required for Islington.—As will be seen from our advertisement columns, the Vestry of the Parish of St. Mary, Islington, invite tenders for supplying and erecting plant and machinery for the supply of electricity, and for supplying the conduits and mains, which will be laid by the Vestry. The specification is divided into the following sections: (1) boilers (Lancashire), steam and exhaust pipes, pumps and injectors, feed-water heaters; (2) boilers (water-tube); (3) horizontal engines for driving alternators; (4) engines for driving arc lighting dynamos; (5) alternators and exciters; (6) main switchboards and instruments; (7) continuous-current series dynamo, with instruments, arc lamps, and lamp-posts; (8) testing and other instruments; (9) conduits, street boxes, etc.; (10) single and concentric mains. Contractors may tender for the whole or any one or more sections. Application may be made for the specification, general conditions, and form of tender to Mr. Albert Gay, electrical engineer, Vestry Hall, Upper-street, Islington, on and after the 19th inst. A charge of £1. 1s. per section will be made for plans and specifications, but this sum will be returned on receipt of a bona fide tender. Sealed tenders to be addressed to Mr. Wm. F. Dewey, vestry clerk, at the Vestry Hall, Upper-street, and delivered not later than March 21.

The Northern Society of Electrical Engineers.—The following candidates were recommended on the 9th inst. by the council to be balloted for as members: Francis G. Bailey, M.A., University College, Liverpool; William Banks, 32, Corporation-street, Bolton; Alfred Bellamy, J. E. H. Andrew and Co., Reddish; John C. Chambers, P.O. Telegraphs, Leeds; F. Morris Chapman, General Electric Company, Salford; H. J. Coates, General Electric Company, Salford; James Connolly, Connolly Bros., Blackley; John T. Connolly, Connolly Bros., Blackley; R. C. Douglas, Manningham, Bradford; Chris. Elliott, National Telephone Company, Bolton; A. E. Garbutt, Fowler-Waring Cables Company, Newcastle; Robert Hammond, 117, Bishopsgate-street, London; H. W. Heywood, 12, Brazenose-street, Manchester; H. Hirst, General Electric Company, London; Herbert Lindley, Browett and Lindley, Patricroft; Alfred Magnall, National Telephone Company, Warrington; Robert Matthews, Parr's House, Heaton Mersey; E. Alexander Paris, West Norwood, London; John B. Parkinson, York-street, Manchester; Ernest Prestwich, F. H. Royce and Co., Manchester; Percy A. Ramage, Mather and Platt, Manchester; Jos. F. Simpson, 3, Hammerton-street, Burnley; Robt. Taylor, W. T. Glover and Co., Salford; A. Lester Taylor, 36, Dale-street, Liverpool; Arthur P. Wood, Mather and Platt, Manchester; E. H. Nisbett, British Insulated Wire Company, Prescot.

Oriental Telephone and Electric Company.—The directors have issued a circular to the shareholders in which they state that ever since the present Board took office it has been its desire to effect an amalgamation of the two classes of shares, so that there might be one class of shares only, and that dividend-bearing and free from all liability. The litigation in which the Company has been involved was brought about during the endeavours to come to an arrangement with the holders of vendors' shares on the above lines, and arose through a question raised as to the legal interpretation of the agreements between the vendors and the Company in connection with the payment of dividends. Since the decision in the House of Lords, adverse to the interests of the holders of vendors' shares, negotiations have again been opened with the Board by some of the largest holders of these shares, resulting in a committee of the Board meeting the above shareholders. After protracted sittings a provisional agreement has been come to, proposing that there shall be one class of shares of £1 each fully paid-up; that the ordinary shareholders shall receive one such share for every two shares of 11s. paid; that the holder of fully-paid shares shall receive the above shares at the rate of 18 for every 20 now held by him, and the holders of vendors' shares shall receive such shares in the proportion of 15½ for every 20 shares now held by them. The paid-up capital will thus be reduced to £171,497, in place of £199,746; the ordinary shareholders will be relieved from all liability as to calls, and the holders of vendors' shares will come in for immediate dividend. All arrears due to the ordinary shares to be cancelled, and the Company to pay the cost of the recent litigation. The holder of fully paid up shares, and the holders of nearly all of the vendors' shares have agreed to the scheme. A special meeting has been convened for 21st inst., at which resolutions for placing the Company into voluntary liquidation will be proposed. It is hoped that the reconstruction will be carried through before the approaching annual meeting, when a dividend for the past year will be declared.

Claim Over a Contract.—At the Worcestershire Assizes last week, before Lord Chief Justice Coleridge, the New British Electric Light Installation Company, Worcester, brought an action against Mr. E. Bremner Smith, electrical engineer, Oswestry, and Mr. Charles Fitzroy Somerset, Trederwen, Montgomeryshire, to recover £153, balance of amount due for work done. Mr. Vachell appeared for the plaintiff company, Mr. Spearman for Smith, and Mr. Lawrence for Somerset. It appeared from the opening statement of Mr. Vachell that there was practically no dispute as to the amount of the claim. The question was as to who was to pay the costs. The plaintiff company had been compelled to join the two defendants in the action, as each claimed that the other was liable, and the company did not want to have to pay the costs. The defendant Smith applied in April, 1882, for an approximate estimate and suggestions for electrical work for a client of his, and after the specifications had been sent by the plaintiffs, it was revealed that the client was the defendant Somerset, who had a mansion in Montgomeryshire. After the work had proceeded some time, Smith sent to Somerset a certificate for £100 on account, and Somerset drew a cheque for the amount and sent it to Smith, who forwarded it to the plaintiffs. A final instalment became due, and again Smith made out a certificate for £153, the amount now sued for. When payment was applied for Somerset repudiated any contract with the company, and said his contract was with Smith. Smith declined to pay, as he was only the agent of Somerset. After the dispute arose, Smith amended his certificate for £153. 6s. to £137. 15s. 4d., and that amount the plaintiffs were willing to accept. Mr. Lawrence said that Somerset contracted with Smith, and had paid to him the whole amount due in respect of that work. He had paid £230. 10s. and £16. 10s. to other persons and discharged the whole liability. Somerset had nothing to do with the plaintiff company. Therefore, having paid to Smith all he owed, it was not fair to ask him to pay the costs. Mr. Spearman contended that Smith was the agent of Somerset in that and various other works. Somerset did not pay the £130. 10s. 2d. on the second certificate until after action had been taken and Smith had made every effort to get the money. The learned Judge gave judgment for plaintiffs for the £137. 18s. 4d. agreed upon, and ordered Smith to pay the costs of the plaintiffs and of the defendant Somerset. His Lordship said it was quite clear to him that plaintiffs were the sub-contractors of Smith, and that Somerset had nothing to do with the plaintiffs, and was brought into the action by the defendant Smith.

The Lighting Question at Harrogate.—A public meeting, convened by the Mayor (Alderman Fortune), in compliance with a requisition, was held last week "for the purpose of taking into consideration the electric lighting question, and determining as to the expediency of the Corporation undertaking the installation or supply of the electric light at this crisis, now that the public burdens are likely to be much increased." The Mayor presided,

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Mr. Samson Fox moved the following resolution: "That this meeting of ratepayers of the borough of Harrogate does not agree with the Corporation entering into any scheme of electric lighting at the town's expense. and hereby desires them to reconsider the question with the view of transmitting their rights to an independent and private company." The meeting, he said, had been convened by a number of gentlemen who were of opinion that the movement which had taken place in the Council had not been one that was conducive to the best interests of the town from a financial point of view. They were met to ask the Council to reconsider their decision. It was his greatest desire that the town should be lighted by electricity. They did not oppose the introduction of the electric light, but the manner in which the Corporation proposed to go about it. The electric light should be brought within the reach of the poorest cottager. It would be a dangerous thing for the Corporation to take upon itself what so few other corporations had done. Out of a list of 25 towns whose affairs he had investigated, no fewer than 19 had let the electric light undertaking to private companies. This was an example Harrogate would do well to imitate. Alluding to the various other purchases made by the Corporation, which had raised the total of their indebtedness from £110,000, at which it stood two years ags, without the proposed electric scheme, to £220,000, Mr. Fox, while quite admitting that this expenditure had been perfectly justifiable and necessary, urged the Corporation to hesitate before plunging into further debt. The better plan was to let a private company, with its own money and experience, accept the risk of the venture. Mr. M. Harrold seconded the resolution. Councillor Chippendale supported the action of the local authorities. Electricity, he said, unlike gas, fulfilled all the conditions required by health. It would be a very expensive matter to have a company introducing the light into Harrogate. As to the 25 towns mentioned by Mr. Fox, he could mention 25 others, only four of which let out their lighting to private companies. He would candidly admit that the scheme might not pay at first, but it was his belief that it very soon would do so. Councillor D. S. Ward also spoke in favour of the action of the Corporation. Mr. G. Whitehead moved an amendment that the progress made in electric lighting in a number of other towns and cities in England and abroad justifies the action of the Harrogate Town Council in taking and developing electric lighting in the borough, in addition to keeping and protecting all the public rights obtained in the provisions secured to them by Parliament. He mentioned various important towns which had controlled their own lighting, and made good profits thereby. If the profits made by the local gas and waterworks companies had accrued to the Corporation, they would have reduced the rates one-half. Mr. Johnson seconded the amendment. Eventually the resolution was carried by a majority. At the quarterly meeting of the Town Council on Monday, Mr. Meyer moved, in view of the recent town's meeting, to rescind the resolution "That the Council will itself carry out the electric lighting order." Alderman Milner seconded the motion, which was rejected. After discussion the original minute to accept the tender of the British Wire Company for cables, subject to the consent of the Local Government Board, was confirmed by 13 votes to 8.

Lighting of Stafford. — The clerk to the Town Council mentioned last week that the Local Government Board would be prepared to sanction the proposed loan of £20,000 for the purpose of electric lighting, and to give their consent under Article 7 of the Stafford Electric Lighting Order, 1890, to the appropriation of certain land at the gasworks to such purposes on being furnished with a tracing showing by different colours the land proposed to be so appropriated, and also the portion proposed to be purchased for the same purpose at a cost of £500. The Board wished at the same to be informed whether a provisional agreement had now been entered into for the acquisition of the land which was to be purchased. The Electric Lighting Committee reported at the same meeting that the engineer, Mr. Bell, had had several interviews with Dr. Hopkinson, and that the necessary plans, drawings, and specifications were ready for obtaining tenders for buildings, engines, boilers, dynamos, etc. The committee recommended that the portion of land shown on the plan submitted, containing 1,224 square yards, now forming part of the gasworks site and not required for gasworks purposes, should be acquired by the Council for electric lighting purposes at a cost of £125. The committee further recommended that the town clerk should be instructed to prepare the necessary documents and also an agreement with Messrs. Bostock as to easement for laying pipes and cables along their private road. Mr. Bell had been instructed to engage a quantity surveyor at a remuneration not to exceed 1¼ per cent., exclusive of cost of lithographing. The report also contained a recommendation that tenders be obtained for electric lighting machinery and other necessary works. Alderman W. H. Peach proposed the adoption of the report. He observed that very considerable progress had been made since the last report towards carrying out the powers of the Council by the provisional order of 1890, inasmuch as the sanction of the Local Government Board had been obtained and drawings of the proposed new central electric supply station were now submitted. The committee confirmed their previous recommendation that the best and most suitable site for the new works which could possibly be obtained was the land adjoining the gasworks, and, in order to allow ample room for future extensions, it was necessary for the Corporation to purchase land and make arrangements as mentioned in the report. The object in obtaining this land was to facilitate the extension of works when required. The new works had been so designed that the whole building could be duplicated without alteration or demolition. The buildings would consist of a large engine and dynamo house 40ft. wide and 82ft. long, sufficient room being allowed for the reception of three 100-h.p. engines and two 200-h.p. engines, with dynamos, when necessary. The boiler-house would be 41ft. wide and 56ft. long, with chimney measuring 7ft. at the base and 120ft. high. Three steam-boilers of the Lancashire type, to work at a pressure of 125lb., would be put in, and these would supply the gasworks with steam in addition to the electricity works. Room would be allowed for a fourth boiler to be added at any future time. Facing Messrs. Bostock's factory would be erected a two-storey building, 73ft. long and 17ft. wide, which would contain accumulator-room, workshops, offices, etc., on the ground floor, the upper floor being reserved for stores, showroom, and for testing purposes. The buildings would be constructed of red pressed bricks, with blue and stone mouldings, and the dynamo-room would be lined with glazed bricks. Dr. Hopkinson had recommended that three horizontal compound high-pressure steam-engines should be put down, each capable of giving at least 100 h.p., and everything would be arranged so that two additional engines could be added, each of 200 h.p. He also recommended that three dynamos should be put down, each to be driven by belting from engine flywheels. These dynamos would be continuous-current machines, each capable of giving 300 amperes at 220 volts when the dynamos were running at about 600 revolutions per minute. A battery of accumulators would also be put down, containing 112 cells, which would supply the light day loads and the supply after midnight, so that at first only one, or at most two, gangs of men need be employed during the day and evening. The capacity of the station would be such that 5,000 16-c.p. lamps could be wired before extensions were required, and if a revenue of only 12s. per lamp wired per annum were obtained, this would mean an income of £3,000, which would pay for the working expenses, interest on a capital of £15,000, redemption of the same in 30 years, and leave a margin of profit in reduction of rates. The capital required could be borrowed at 3½ per cent. interest and repaid in equal annual instalments of principal and interest during 30 years, which meant an annual payment of £790. The estimated working expenses, including repairs and maintenance, came to £1,250, making a total of £2,140. The committee had very great hopes of making the scheme pay, and had every reason to believe that they would make a profit out of the concern in a couple of years. Alderman Silvester seconded the adoption of the report, which was carried.

Lighting of Monmouth.—A letter was read last week at a meeting of the Town Council in reference to the application of the Town Council for sanction to borrow £18,000 for works of sewerage and sewage disposal and for purposes of electric lighting. The Local Government Board pointed out that as the Town Council have not yet obtained a license or provisional order in respect of their scheme of electric lighting, the Board will be unable to consider this part of the application until such license or order has been obtained. Continuing, the letter stated: "The Board are of opinion, however, that the question of the sewerage and disposal of the sewage of the borough should not be delayed on this account, but should be dealt with at once. Further, they are advised that the pumping of the sewage by turbines as proposed in the original scheme is not likely to be attended with any advantage, and that when looked at apart from electric lighting this scheme cannot be regarded as a good one; and that the Board therefore considers that the Town Council should either modify the present scheme, or select one of the schemes submitted in answer to their advertisement, and apply for the Board's approval thereof as soon as possible." The Mayor remarked that this letter did not mention the amended scheme which Mr. Lailey submitted on December 16, and on the receipt of the letter, therefore, he wrote to the Local Government Board, drawing attention to the amended scheme. The reply received was to the effect that the Local Government Board's letter of January 17 was written after full consideration of the modified scheme sent by Mr. Lailey. The Mayor remarked that these letters opened up a very serious matter. The letters were not of the satisfactory nature he could have wished. At the same time he saw nothing to induce him to alter the opinions he had held up to the present time, and he was of opinion still, that it was only to the ultimately combined schemes that they could reasonably look for relief in the heavy expenses they were to undertake in respect to the drainage. And if they could not get this project accepted as a combined scheme—which after these letters he saw no chance of doing—the next best thing was to try and get it through in two halves, and he should himself suggest that they should postpone, for the time being, the electrical portion of it until such time as they were in possession of the order. They could reintroduce the matter and confine their attention to the sewerage portion of the work, but upon lines that would ultimately dovetail in with the electrical portion. With this object in view, the proposal made by Alderman Vizard at their last meeting would come in as the very thing they wanted. The Local Government Board did not condemn their scheme, but, looked at apart from the electric lighting, they said they did not consider it would be a good one. And the same opinion had been expressed all along. If they had to do their purification by steam, they would be landed into an expense of £100 or £200 per year, and if they could not utilise water for the electric lighting, the expenses would be quite £300 a year over and above the amount of the water estimate. It was undoubtedly to the water scheme that the Local Government Board objected, and they had based their objection upon the report made by the inspector. The same remark would apply to the site for the pumping works. That was the only site in which they could employ water, and in view of the ultimate joining of the two halves of the scheme they must cling to this site. To remove this uncertainty as to whether the water would act or not, Mr.

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Vizard's motion came in. The town clerk, in accordance with instructions given at the last meeting of the Council, had communicated with the Institute of Civil Engineers, asking for the names of one or two gentlemen qualified to act for them as hydraulic inspectors, and the names submitted in reply were those of Mr. Unwin, and Messrs. Bramwell and Harris. They had these gentlemen's terms, and he had written himself to a maker of turbines, a Mr. Gilkes. He strongly advised now that these gentlemen should be engaged, either to convince the Board that water was suitable as a motive power or to prove that the ideas held on the subject in that Council were incorrect. If the reports were favourable they could send them to the Local Government Board with a request that the drainage portion of the scheme be allowed to go through on the lines indicated by Mr. Lailey on December 16. so that it would ultimately dovetail in with the electrical lighting portion when that came on. Mr. Lailey proposed at his own expense to submit his portion of the scheme to a member of the institute also, and the report from that quarter could also accompany the one from Messrs. Bramwell and Harris. Mr. Unwin was unable to take the inspection in hand. Messrs. Bramwell and Harris's charge was 30 guineas, and out-of-pocket expenses for travelling. There was another point. No doubt Messrs. Bramwell and Harris based their calculations upon what they knew makers of hydraulic machinery could do, but he thought at the same time that a guarantee from a maker of machinery himself would carry a great weight. He had therefore written to Mr. Gilkes, who happened to be the man who quoted the Brush people for turbines, and he had learned that he was prepared to come for £5. 5s. per day, in addition to travelling expenses. Although it might appear, at first sight, injudicious to have a man who might be regarded as almost interested in the matter, they would see that an engineer who might be called upon to manufacture must be careful about the advice he gave. He formally proposed that these men be engaged to come down, to meet upon the ground, and to examine into and report upon the scheme the Council hoped to carry out. This motion was ultimately adopted.

PROVISIONAL PATENTS, 1894.

FEBRUARY 5.

2451. **Improvements in and connected with electrical concentric conductors.** Carrington Riddell Gordon Smythe, 5, Doune-quadrant, Kelvinside, Glasgow.

2452. **Improvements in thermo-dynamic motors.** Francis William Crossley and James Atkinson, Openshaw, Manchester.

2453. **Improvements in thermo-dynamic motors.** Francis William Crossley and James Atkinson, Openshaw, Manchester.

2487. **Improvements in or relating to secondary batteries.** Charles James Hall, 433, Strand, London.

2493. **Improvements in holders for electric incandescence lamps.** Richard Francis Randell, 55, Chancery-lane, London.

2514. **Improvements in or relating to electric bells.** Julius Henrik West, 24, Southampton-buildings, Chancery-lane, London. (Complete specification.)

2524. **An electromotor for fans.** Blackman Ventilating Company, Limited, 28, Southampton-buildings, Chancery-lane, London. (Felix Stahl, Germany.)

FEBRUARY 6.

2548. **Improvements in firing keys or electrical contact makers.** Herbert Vivian Keeson, 40, Loudoun-road, St. John's Wood, London.

2562. **Improvements in electrical tramways and railways.** Frank Merwin Ashley, 70, Market-street, Manchester. (Complete specification.)

2607. **An improved magnetic electric conduit system for electric tramways, railways, and the like.** Robert Flebbe, 22, Glasshouse-street, Regent-street, London.

2623. **Improvements in regulating and controlling dynamos.** William Morris Mordey, 46, Lincoln's-inn-fields, London.

FEBRUARY 7.

2677. **An improved printing telegraph and transmitter.** Charles Austin Beck and Leo Kamm, 1, Gresley-road, Hornsey Rise, London.

2693. **Improvements in or connected with phonographs.** Ernest Otto Kumberg and Bernard Eleazar Clarke, 33, Chancery-lane, London.

2721. **Improvements in and connected with insulators for supporting electric telegraph, telephone, and similar conducting wires.** Tyson Sewell and Hans Bodtker, 163, Queen Victoria-street, London.

FEBRUARY 8.

2730. **A new and improved protector for electric cables laid underground.** Thomas Barnet Grant, 15, George-street, Mansion House, London.

2733. **Improvements in or relating to the regulating mechanism of electric arc lamps.** William Charles Mountain and George Theodore O'Brien Carew, 3, St. Nicholas-buildings, Newcastle-on-Tyne.

2734. **An improved electrical contact screw.** James Howard Kerr, 9, Westland-row, Dublin.

2749. **A new or improved register and holder therefor for recording telephonic messages.** Dyson Denison, 2, Market-street, Bradford.

2790. **An improved electric registering apparatus for recording the speed and occupation of vehicles.** Fritz Klaege, 18, Buckingham-street, Strand, London.

2800. **Improvements in incandescent lamp fittings.** Eugéne François Alexandre Soleau, 53, Chancery-lane, London.

2806. **Improvements in electrolytical decomposing apparatus.** Carl Kellner, 46, Lincoln's-inn-fields, London.

2812. **Improvements in methods of and apparatus for the generation of electric currents of defined period.** Nikola Tesla, 45, Southampton-buildings, Chancery-lane, London. (Date applied for under Patents, etc., Act, 1883, Section 103, August 19, 1893, being date of application in United States.) (Complete specification.)

FEBRUARY 9.

2851. **Improved electric signal apparatus.** William Paul Theermann, 11, Great Ducie-street, Manchester.

2866. **Improvements in and having relation to dynamo-electric machines.** William Lloyd Wise, 46, Lincoln's-inn-fields, London. (Isaac Newton Lewis, United States.)

2897. **Improvements in the manufacture of coke or carbon for electrical or other purposes.** Charles Percy Shrewsbury, Frank Lawrence Marshall, John Cooper, and John Laskey Dobell, 57, Chancery-lane, London.

2900. **Improvements relating to the electro-deposition of metals.** Josef Rudholzner, 45, Southampton-buildings, Chancery-lane, London. (Complete specification.)

FEBRUARY 10.

2936. **Improvements applicable in connection with telemotor apparatus for actuating mechanism at a distance for telegraphing, indicating, steering, and analogous purposes.** Andrew Betts Brown, 87, St. Vincent-street, Glasgow.

2965. **Improvements in holders for incandescent electric lamps.** Julius Herman Geisenheimer and Ernest Augustus Lessing, 4, South-street, Finsbury, London.

2968. **An improvement in electrolysing liquids and apparatus therefor.** Oliver Imray, 28, Southampton-buildings, Chancery-lane, London. (The Farbwerke vormals Meister, Lucius, and Brüning, Germany.)

2976. **Improvements in casings and fittings for electric wires and lights.** Henry Vaughan Lanchester, 13, Bedford-row, London.

SPECIFICATIONS PUBLISHED.

1883.

982. **Telemeter systems.** Brookes. (Dibble.)
983. **Telemeter systems.** Brookes. (Dibble.)
1697. **Electric clock.** Binswanger and Coates.
2203. **Arc lamps.** Gwynne.
2403. **Distributing electrical energy.** Kingdon.
5101. **Electrically interlocking signals and points.** Fletcher.
5778. **Bleaching solutions by electrolysis.** Boult. (Knoefler and another.)
7703. **Electric signalling for railways.** Johnson. (Lattig and another.)
10623. **Printing telegraphs.** Murray.
21430. **Electric lamps.** Robertson.
21734. **Dynamo-electric machines.** Wilson.
21850. **Voltameters.** Naber.
22131. **Electric switches.** Lowrie.
22594. **Electric lamps.** Davy.
23017. **Arc lamp.** Low and Brown.
23897. **Electric signalling.** Reed.
23913. **Dissociating soluble salts by electrolysis.** Haddan. (Blackmore.)

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	2⅜
— Pref.	—	2¼
Charing Cross and Strand	—	5
City of London	—	11½
— Pref.	—	13½
Electric Construction	—	1⅜
House-to-House	5	2
India Rubber, Gutta Percha & Telegraph Co.	10	24½
Liverpool Electric Supply	5	6¼
	4½	5½
London Electric Supply	5	1
Metropolitan Electric Supply	—	8⅜
National Telephone	5	4⅜
St. James', Pref.	—	6⅜
Swan United	3½	3⅜
Westminster Electric	—	5½

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NOTES.

The "Faraday House Journal."—A copy of No. 2 of this journal has reached us.

Derby.—The new Midland Institute, which has just been opened, is lighted throughout by electricity.

The Electro-Harmonic Society.—As stated in our last issue, a ladies' night of this society will take place this (Friday) evening at St. James's Hall Restaurant, Regent-street, W.

The Madras Electric Tramway.—It appears that progress is being made with this tramway, and that the central station is approaching completion. The engineers hope soon to be laying over 200ft. of double line per day.

Enfield.—It appears that the Enfield Local Board, in reply to advertisements, have not received any tenders for the lighting of the locality by oil. The Local Board should consider the advisability of introducing the electric light.

Newport.—The chairman of the Newport Gas Company imagines that the supply of electricity by the Corporation will entail a loss, "as elsewhere." Why does Mr. E. G. Phillips not be sure of his statements before he makes them?

New Launch.—A new launch, the "Britannic," built by the Thames Electric and Steam Launch Company, was put in the water on Wednesday at Eel Pie Island, Twickenham. The launch is 75ft. long, and is the largest constructed on the upper reaches of the Thames.

Transformers and Alternators.—Messrs. Pyke, Harris, and Co., Limited, have issued new lists containing particulars of some of their specialities. These include small transformers, vacuum tube letters, and alternators for lighting and laboratory purposes.

Yorkshire House-to-House Electricity Company.—We have received a copy of the report and accounts of this Company, to be presented at a meeting to be held on Tuesday, March 6, at the offices of the Company, Whitehall-road, Leeds, at 2.30 p.m. The report and accounts will be published in our next issue.

Bournemouth.—The Sanitary Committee of the Town Council last week reported that they had deferred consideration of the surveyor's report with reference to flushing the sewers with fresh water, in order that Mr. Lacey might obtain information with reference to the Hermite system of electrolysing sea-water, by which it is converted into a disinfectant.

University College Chemical and Physical Society.—The annual public address will be delivered in the Chemical Theatre of University College, Gower-street, W.C., by Prof. J. Millar Thompson, F.R.S.E., on Wednesday next, the 28th inst. The subject is "Some Phenomena Connected with Solution and Crystallisation." Prof. W. Ramsay, F.R.S., will take the chair at 8 o'clock.

New Cables.—During the past year the Telegraph Construction and Maintenance Company have laid a cable between Bonny and Cameroons for the African Direct Telegraph Company. A second, connecting the Azores Islands with Lisbon, for the Europe and Azores Telegraph Company, and a third from Zanibar to the Seychelles and Mauritius for the Eastern and South African Telegraph Company have also been laid.

"Directory of Telegraphic Addresses."—Mr. H. Sell has now been successful in producing his "Directory of Telegraphic Addresses" in a complete form by the addition to the present (eighth) edition of telegraphic addresses, obtained from official lists supplied by the authority of the Postmaster-General. The telegraphic and other addresses of upwards of 40,000 firms are given, besides other useful information, including a gazetteer of the leading towns in the kingdom.

Lectures.—The Carpenters' Company has arranged for a short course of six lectures to be delivered at their hall in London-wall on Wednesday evenings on matters connected with building. Several of them are likely to be of considerable interest, not only to working-men engaged in the building trade, but to all students of electricity, engineering, and architecture. The first lecture, by Prof. Unwin, F.R.S., was delivered on Wednesday, the subject being "Niagara and the Works for its Utilisation."

Royal Meteorological Society.—The monthly meeting of this society was held on Wednesday evening at the Institution of Civil Engineers, Westminster, Mr. R. Inwards, F.R.A.S., president, in the chair. Papers were read on the following subjects: "Temperature, Rainfall, and Sunshine at Las Palmas, Grand Canary," by Dr. J. Cleasby Taylor; "Report on the Phenological Observations for 1893," by Mr. E. Mawley, F.R.Met.S.; and "Comparative Observations with two Thermometer Screens at Ilfracombe," by Mr. W. Marriott, F.R.Met.S.

"Electrical Literature."—This is the title of a monthly publication which is intended to supply a brief synopsis, in a classified form, of each important article and editorial that may have any bearing on any phase of electrical engineering appearing in any publication, either American or foreign. It is a continuation of the synoptical index formerly appearing in *Electrical Engineering*. Only one subject appears on a sheet, the reverse of the sheet being blank, and each subject sheet is indexed independently of the running page number of the volume.

Fountain-Lighting.—The Warminster Local Board have accepted from Mr. W. F. Morgan, the chairman, on behalf of the town, a drinking fountain of red granite erected in the Market-place. An electric arc lamp has been placed at the summit of the fountain. The arc lamp is of the Brockie-Pell type and of 2,000 c.p., and the current is obtained from the electric lighting plant of Mr. Mark Hill, of the Station Sawmills. Provision has been made for the erection of three additional lamps, by means of which the whole of the Market-place will be lighted by electricity.

Electrical Apparatus.—A new catalogue of electrical apparatus has been issued by Messrs. Dorman and Smith, of Ordsal Electrical Works, Salford, and 11, Grocers' Hall-court, Cheapside. Among the firm's manufactures, which are now well known, may be mentioned holders for base loop and base-capped lamps, suspension holders, the D. & S. porcelain switches of various types, carbon break switches, and main switches and switchboards. In addition to these, the firm make accumulator regulators, distributing fuse-boxes, wall sockets, and a large variety of electric light fittings.

Village-Lighting.—As stated in our last issue, the village of Great Missenden, on the Metropolitan Extension to Aylesbury, is now lighted by electricity. A 15-h.p. steam-engine drives a small dynamo which supplies 15 lights of 32 c.p. each. The conductors are carried on wooden posts, and the charge for keeping the lamps alight up to half-past ten on dark nights will be £15 per annum. The company (the British Volta Electric Glow Lamp Company) who has introduced the supply expect a considerable demand for the light for domestic purposes, and will also supply it for cooking.

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Smoking Concert.—Last Friday evening the staff of the City of London Electric Lighting Company, Limited, assembled, together with several friends, at the London Tavern, Fenchurch-street, at a smoking concert organised by the City Electric Athletic Club. The chair was taken by Colonel H. C. Seddon, who was supported by Mr. Bull, secretary of the company; Mr. Cooke, the manager; and Mr. E. J. Frowein, Mr. R. Hunter, Mr. A. F. Harrison, and Mr. S. T. Jordan, the four last named forming the committee of the entertainment. A varied and good programme was provided.

The Government and Telephony.—Mr. A. Morley, replying to Captain Bagot in the House of Commons, on Tuesday, said that under the agreement now in course of negotiation, the Post Office will take over the entire trunk-wire system of the country, and pending the completion of the agreement the company have undertaken to abstain from laying down any new trunk wires. The Post Office is now itself gradually carrying out the scheme of providing trunk wires between the important towns of the United Kingdom, and the claims of Kendal will be duly considered along with those of other towns.

Lighting at Cardiff.—A deputation of members of the Lighting and Electrical Committee of Cardiff Corporation visited Bristol last Friday for the purpose of inspecting the system of public and private electric lighting now in operation there. The deputation, under the guidance of the local engineer (Mr. Proctor) examined the plant and apparatus at the generating station during the early part of the day, and in the evening they saw the lighting both in the public streets and in various business places and private houses. At a forthcoming meeting of the committee the deputation will make an informal report containing several interesting points on the matter.

Caustic Soda and Bleaching Powder.—The prospectus has been issued of the Electro-Chemical Company, Limited, the registration of which is announced in another column. The company is being formed with a capital of £200,000, divided into 40,000 shares of £5 each, for the purpose of working in the neighbourhood of the coal and salt fields in the North of England, the electrolytic process for the decomposition of salt, and the production thereby of caustic soda and bleaching powder, that has for the past two years been carried on at Snodland, Kent. The reports accompanying the prospectus are by Dr. J. Hopkinson, Mr. J. Swinburne, Mr. J. Leith, and others.

Tramway Traction and Lighting.—Mr. W. J. Carruthers-Wain mentioned on Monday, at a meeting of the London, Deptford, and Greenwich Tramways Company, that the Connolly oil-motor would soon be running again on the company's lines. He stated that one method of increasing the traffic was to make the cars as attractive as possible by fitting them up with the electric light. Hitherto the difficulty and the expense have been drawbacks, but the speaker understood that they were now within measurable distance of having electric light supplied to them which would be steady, effective, and cheap. If it combined those attributes, they would be only too glad to introduce it in the cars.

The Extraction of Zinc.—An electrolytic process for the extraction of zinc, says *Engineering*, is attracting much attention in Sweden, where some very telling and satisfactory tests have been undertaken. The zinc extracted in this manner is equal to the best zinc in the market. The most important point in connection with the new process lies in the fact that it can be applied to zinc ore of very poor quality (for instance, the sulphur ore found at Faln), such as the Vieille Montagne Company have not thought it worth their while to exploit. Pure metallic zinc has not been produced in Sweden for some 20 or 30 years, whilst the imports into Sweden of zinc are of some importance.

The Niagara Power Station.—The first practical test of the hydraulic tunnel which has been under construction at Niagara Falls during the past three years, was made on the 25th ult. The test afforded a practical demonstration of the new works, which have already cost nearly £800,000. The Niagara Falls paper mill, which is the first to get the benefit of the power, is the largest of its kind in the world. Its contract is for 6,600 h.p., one-half of which is being used now, and the cost, including the lease of the land occupied by the mill, is 32s. per horse-power per year, for 24 hours per day, the cheapest, it is said, ever obtained. The mill is now in full operation. The hydraulic tunnel has a capacity of 120,000 h.p. The formal opening of the general power-house, where 5,000-h.p. turbines will operate 5,000-h.p. electric generators for the transmission of power, is announced to take place on June 1.

Electric Light Fittings.—Judging from the large catalogue of electric light fittings which has reached us from Messrs. B. Verity and Sons, of Aston, Birmingham, practically every article or appliance included under this head is produced by the firm. Even this is distinct from the catalogue of high-class London fittings, an *edition de luxe* of which is now being issued by the London house of the firm in King-street, Covent Garden. The present catalogue, which is divided into 21 sections, deals with brass or brass and copper brackets, combination gas and electric brackets, electroliers, coronæ and billiard lights, sliding pendants, shade lamps and brass standards. Apart from these, there is a large and varied selection of similar fittings in wrought iron, or iron and copper, and a collection of ship and mine fittings, brackets, and lamps for external use, reflectors, glass and opal shades, and silk, paper, and cardboard shades.

The Pacific Cable Scheme.—Mr. Sandford Fleming, director of the Canadian Pacific Railway, published on the 15th inst. a reply to the strictures of Mr. John Kidd, the Postmaster-General of New South Wales, on the Pacific cable scheme. He said that Mr. Kidd, if he was properly reported, is the only public man in Australia who entertains views antagonistic to the scheme. Every objection to the project will be met, he adds, when the conference of colonial representatives assembles at Ottawa next June. The Hon. Robert Reid on Monday met the members of the Colonial party of the House of Commons, who had assembled in one of the committee-rooms to hear an address from that gentleman, who is Minister of Defence for the Colony of Victoria, on "Colonial and Imperial Defence." The hon. gentleman advocated the construction of a telegraphic cable across the Pacific in conjunction with the Governments of Canada and Australia, and improved postal communication.

Search-Lights on the Manchester Ship Canal.—Since the opening of the Ship Canal for traffic many ship-owners and master mariners have been rather afraid they would be unable to navigate the canal successfully during the night, and hitherto only one or two of the regular coasting vessels have attempted the task. A Manchester firm have brought forward a powerful electric search-light, by means of which the captain of a vessel can navigate the canal during the night with the same ease as during the day. The responsibility of the search-light rests upon Mr. W. J. Croft, who has had much experience with it in many parts of the world. The search-light consists of a 24in. projector, with the necessary mirrors and reflectors, and is

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supported in a cradle, so that the light can be thrown in any direction. In addition to the search-light, which has a candle-power of between 40,000 and 50,000, a light of between 8,000 c.p. and 10,000 c.p. can be placed at the mast-head of a vessel when loading. The "Ohio" was the first vessel to try the light on the canal recently, but owing to her lightness and the heavy gale she was unable to leave her moorings. The search-light, however, was tried, and Captain Atkinson expressed great satisfaction with it. Mr. Croft has adhered to the canal regulations, and by certain arrangement of the lens it is said that no inconvenience will be caused to vessels coming in an opposite direction to that carrying the light.

Engineering Trade Section of the London Chamber of Commerce.—A meeting of this body was held on Monday, Mr. W. J. Fraser occupying the chair. The question of the Antwerp International Exhibition, 1894, was brought prominently before the meeting with a view to inducing the members of the section and the trade generally to exhibit. It was stated that the exhibition was a very promising one, as Antwerp was an important seaport visited by merchants and all classes from all parts of the Continent and within easy reach of England; that the duties in Belgium were low; that it was under Royal patronage; and that a joint committee representing the Mansion House and the London Chamber of Commerce was acting in London in the interests of the British section. After an expression of opinion it was proposed by Mr. Fortescue Flannery, J.P., seconded by Mr. A. Brebner, and carried unanimously: "That in view of the great progress recently made by engineering science on the Continent, and the prominent and accessible position of Antwerp as a site for exhibition, the engineering section of the London Chamber of Commerce cordially recommends the forthcoming Antwerp exhibition to the general support of the engineering and allied trades throughout the United Kingdom." It was then proposed by the chairman, seconded by Mr. Brebner, and carried unanimously: "That the chairman of this section, Sir Edward H. Carbutt, Bart., be requested to confer with the exhibition authorities as to the appointment of jurors for the engineering section."

Magnetisation by Very Small Forces.—A paper on this subject by Mr. P. Culmann was recently published in the *Elektrotechnische Zeitschrift*, and a *résumé* of it is given in the "Foreign Abstracts" of the Institution of Electrical Engineers. The author pointed out that in 1887 Lord Rayleigh published experiments which went to show that for forces from $4/10^5$ to $4/10^2$ C.G.S. units (unannealed Swedish iron wire) the magnetisation was directly proportional to the magnetising force. Herr Roessler in a recent series of articles has cast doubts on the accuracy of this conclusion, since he found deviations from proportionality amounting to 20 per cent., and he puts down Lord Rayleigh's failure to observe this to his method of observation, in which he only measured a presumably minute difference between quantities in themselves very small. The author does not agree with this objection, holding that Lord Rayleigh's method, in which differences alone are observed, must necessarily be more accurate than one in which the difference is between two larger deflections, of which it forms but a small proportion; and though the observed quantity is small, much more sensitive apparatus can be used (in Lord Rayleigh's experiments an $H = 0{\cdot}00004$ C.G.S. unit gives a deflection of 1·5mm., and this is about 50 times the sensitiveness of Herr Roessler's method). The author has calculated the amount in actual length of the deviation from proportionality observed, which is 0·25mm., and therefore concludes that we need not modify our views on the laws of very weak magnetisation as formed some time since on the basis of Lord Rayleigh's research.

Testing of House Installations by Supply Companies.—We are pleased to give space to the following circular which has been issued by Mr. David Cook, engineer and manager to the City of London Electric Lighting Company, Limited: "The attention of the company is frequently drawn to defective insulation of electric conductors and fittings on consumers' premises. This may arise in a great variety of ways, but chiefly through employing inferior material and workmanship in wiring the buildings or allowing good installations to get into disrepair. When considerable leakage occurs, the meters may register the lost current as if used by the consumer. Damage to buildings and fittings may also be occasioned. Unless careful tests are made by skilled men, leaks and incipient faults may long remain undetected, growing worse as time goes on. At present there is no public or other body charged with the duty of making tests on private premises, although an opening appears to exist for a testing authority of the kind. With the object of filling this want and placing within the consumer's reach a ready means of lessening any loss or risk, the City of London Electric Lighting Company, Limited, hereby gives notice that it is prepared to enter into agreements with consumers to examine their fittings, etc., at stated intervals on payment of an annual fee of 10s. The men who make the test will hand the consumer a signed report specifying the insulation resistance, with a note on the general condition of the wires and fittings at time of inspection."

The E.M.F. of Starlight.—Mr. George M. Minchin writes to *Nature* from Westmeath, whither he went with the object of trying whether or not it is possible to obtain measurable E.M.F.'s from the light of the planets and the fixed stars. After one night's work, Mr. Minchin was able to announce the remarkable discovery that, with the apparatus he employed for the purpose, the E.M.F. of starlight is easily measurable. The electrometer employed was Clifton's form of the quadrant electrometer of Lord Kelvin. The telescope was Mr. Wilson's 24in. reflector; and the photo-electric cell, attached to a cell-carrier was connected with the telescope in place of the eyepiece, and could be moved in and out of the image of the star at pleasure. The area of the sensitive plates in the cell was about three square millimetres. A force of one volt was represented by 460 divisions of the scale, and the light of Venus gave something like 40 divisions. Only about one-quarter of the disc of the planet was then illuminated, so that its whole light would be represented by 80 divisions. Thus the light of Venus when concentrated by this telescope is represented by about 0·17 volt. With Jupiter, about 14 divisions on the scale were obtained, but no conclusion can be drawn from this, because the image of Jupiter covered much more than the area of the sensitive plate. From the light of Sirius a force of 0·02 volt was obtained, being a little over nine divisions on the scale. An attempt on Aldebaran was not productive of any certain result. Mr. Minchin observes that the relative values of the lights of Venus and of Sirius as given in the "Encyclopædia Britannica," article "Photometry," are most probably erroneous, the brilliancy of Venus being greatly underrated.

The Hermite Process at Worthing.—In the course of a communication to the *Lancet*, a correspondent says: "It is expected that shortly the experimental plant and machinery which have been erected in West-street will be quite ready for demonstration by M. Hermite. The Town Council have consented, as a preliminary test experiment, to place a small row of houses at the disposal of M.

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Hermite, in order that he may demonstrate the working conditions of the process. For this purpose the houses have been fitted with cisterns and pipes to supply the 'electrolysed fluid' for flushing purposes. At present the sewers are laid open to admit of inspection when the whole plant is in action. The treated sewage discharge is to fall into an intercepting syphon fitted with a screening arrangement, into which solid matters are temporarily deposited, but by the continued flow of 'electrolysed fluid' over this deposit the fæcal matter, so it is asserted by the inventor, is disintegrated and gradually destroyed. The plans and arrangements at this experimental station have been carried out under M. Hermite's instructions. The Town Council are moving no more in the matter for the nonce than to offer M. Hermite every facility for carrying out a fair experiment. Disappointment has been expressed in several quarters at the seeming delay of the trials which have been announced pretty freely in the press to take place shortly, but the electrical engineers appointed by M. Hermite have got to work, and they have for some time been steadily fixing the necessary plant and adjusting it to meet the especial requirements of the present case. The date of the trial is not definitely fixed, but the inaugural ceremony will be looked forward to with keen interest."

The Effect of Lightning upon Trees.—It is not for nothing that the "blasted oak" is a familiar adjunct of gruesome fiction. Oaks, according to a scholarly note on the subject by M. Dimitrie, stand a far greater risk than almost any other tree of being struck and injured by lightning. M. Dimitrie's experiments were conducted with a Holtz electrical machine, and samples of different woods. Under similar conditions the spark would penetrate oak in from one to two revolutions of the machine, poplar or willow in five revolutions, beech in from 12 to 20; showing at once a great difference in the electrical conductivity of various woods. The experiments were conducted with living and with dead specimens of wood, and showed that dead wood was more liable to be struck than living. The scientific explanation at the bottom of this difference was found to depend upon the richness or poverty, relatively, of starch and oil. Starch-giving trees, oak, poplar, willow, maple, elm, and ash, oppose much less resistance to lightning than fatty trees, such as beech, walnut, lime, and birch. The fir, which varies greatly with the seasons in regard to its oily contents, can be shown from actual statistics to be as susceptible to lightning stroke in summer as the oak, and as little susceptible in winter as the beech. Bark and foliage are naturally bad conductors, and so is the wood at the core of all trees. In support of his own experiments, M. Dimitrie quotes records from the forests in the principality of Lippe, taken during three different years. The trees struck were as follows: oaks 159, beech 21, pitch pine 20, firs 59, various other trees 20. The relative numbers of these trees in the forests were: oaks 11 per cent., beech 70 per cent., pitch pine 13 per cent., and fir 6 per cent. The risk to pitch pine is thus five times, to fir 33 times, and to oak 48 times greater than it is to beech. These results are curious and noteworthy.

The Aberdeen Electric Light Station.—The inaugural ceremony of setting the plant in operation at this station is announced to take place on Tuesday next, the 27th. The Town Council obtained a provisional order in 1890, and the system adopted is based upon a report by Prof. A. B. W. Kennedy. The initial stages of the work were begun before the appointment of an electrical engineer, but since September last the station has been in the hands of Mr. E. T. Ruthven-Murray, the electrical engineer. The generating station in Cotton-street will be capable of supplying 10,000 lamps of 8 c.p. The electric light undertaking is to be worked in conjunction with the gasworks, an arrangement which was adopted in view of its economy and efficiency. The station is in the grounds of the gasworks. The building comprises three main parts—namely, the boiler-room, the engine and dynamo room, and the battery and switchboard room. In the basement is situated the boiler-room, which contains four Babcock and Wilcox boilers. Three of these are of 90 h.p. each, with a working pressure of 150lb. The feed-water is heated by means of the exhaust steam. On the same floor as the boilers, but separated from them by a wall, is the engine and dynamo room, which has space for the erection of additional plant when necessary. At present it contains five engines, two of these being of 40 i.h.p., running at 520 revolutions per minute; and three engines of 80 h.p., running at 480 revolutions per minute. These engines are all coupled direct to corresponding dynamos of the Elwell-Parker type. The switchboard is arranged in the same room as the dynamos. Storage batteries will be used to meet the requirements when the demand for light is low. From the station the current is conveyed by means of copper conductors arranged in concrete culverts. The engine-room has accommodation for additional machinery to the extent of 1,500 h.p., so that extension of the buildings will not be necessary for a considerable time.

Alternate-Current "Rectifiers."—The advantages of alternating currents are many and important, but by no means exhaustive so far as the practical requirements of electric lighting and power applications are concerned. They have hitherto failed wholly to serve for charging accumulators on a reasonable scale, or in carrying out any of the more usual processes of electro-chemistry; besides which, their employment for actuating small motors—such as might be installed in a private house, factory, warehouse, shop, etc., with energy outputs up to 5 h.p., or, perhaps, 10 h.p.—appears to involve a terrible amount of trouble in the arrangement of suitable and even approximately efficient working conditions. It is therefore hardly to be wondered at that a considerable amount of inventive energy has been spent upon devising apparatus in which alternate currents may be converted cheaply and economically into continuous currents for such purposes as street-lighting and motor work. Amongst the foremost of experimenters in this direction has been Mr. Ferranti, the principle adopted in his apparatus being simply that of a rotary commutator driven by a small alternating motor supplied with current from the alternating mains, synchronously with the supply station generator. The alternate currents are passed through the commutator in such wise that the collecting brushes receive a continuous current, practically as in all continuous-current machines, where the current generated is of an alternating form commuted at the collector. Of course, modifications of this general principle have been devised and experimented upon; and at the present time we understand that important tests upon rectifiers after this kind are being made under the supervision of Mr. W. H. Massey. Mr. Massey is said to be desirous—if it be practically possible—of introducing some such arrangement into the town lighting scheme for Cardiff, which he has in hand. Obviously there are great advantages in direct-current working for the street lamps alone as compared with the use of alternate currents. No reflectors are required in the former case, but the expense of running special mains for the street lights (as in the City of London) and the employment of special machines prove somewhat considerable obstacles in the case of smaller cities and towns. If a small synchronous alternating motor of ½ h.p. at the outside

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is all the mechanism required in a sub-station to convert the alternating into continuous currents by the aid of a rotating commutator, then such an appliance may obtain quite an extensive use under certain conditions. Of course, there are some practical difficulties in the way, and not the least of these appears to be the extreme care necessary for preserving a suitable ratio between the alternating period and the time of commutator rotation. This obstacle may doubtless be fully overcome as our knowledge increases of the working conditions.

A Mountain Electric Railway.—The Mount Lowe Railway, in Southern California, is a remarkable achievement in mountain railway construction. Its object is to connect Pasadena, a beautiful and famous residence city near Los Angeles, with the summit of the Sierra Madre Mountains, nine miles distant and 6,000ft. above sea-level. The mountain road starts from Altadena, a point 12 miles from Los Angeles and three miles from Pasadena, at the terminus of a local steam railway which ascends the foothill mesa of the mountains to an altitude of 1,500ft. The first 2½ miles of the Mount Lowe Railway is an electric trolley line, and climbs up the remainder of the mesa for a mile and a half, and then penetrates Rubio Canyon, a deep and romantic gorge, for another mile. The trolley terminates at Rubio Hotel and Pavilion, a unique structure built across the canyon at an altitude of 2,200ft. From Rubio Hotel, a double-track, three-rail, endless cable incline, 3,000ft. in length, lifts the passenger to the summit of Echo Mountain, 3,500ft. above the sea, overcoming in eight minutes an altitude of 1,300ft., and passing over a varying gradient which ranges from 48 to 62 per cent. Two cars of peculiar construction are provided with transverse seats arranged in three compartments, rising above each other like steps. These cars are permanently fastened to the cable, and one ascends as the other descends, passing each other at an ingenious automatic turnout in the centre of the incline, 1,500ft. from either end. Like the trolley line below, this road is operated by electricity, and is with one or two exceptions the only cable incline in the world operated by electric power. The winding machinery and motor are located in a power-house on Echo Mountain, the plant having been designed and constructed by A. S. Hallidie, of San Francisco. The 1½in. cable is driven by a 75-h.p. Keith electric motor, making 800 revolutions per minute, which, by three reductions, drives a horizontal clip pulley or grip sheave of the Hallidie type, making 17 revolutions per minute. This grip sheave is provided with movable automatic jaws and with a band brake. The conductor of the incline car can signal the engineer at the motor-house at any point on the incline, and stop the car or proceed at will. The dynamo which furnishes the current for the entire system is an Edison bipolar generator, is located in the company's power house at the Altadena station, and is driven by two 60-h.p. Otto gas-engines, the gas being economically manufactured on the premises. An 8in. pipe will shortly be conveying an ample stream of water with a 1,400 foot head to a power-house a mile below the hotel, and two large Pelton wheels will drive the dynamo at a nominal cost. While this great dynamo furnishes power for the trolley line and cable incline, another supplies the electric current for an elaborate system of arc and incandescent lights to illuminate the hotels, canyon, and adjacent grounds.

Economy in the Use of Transformers.—A paper on this subject was recently read by Mr. P. J. McFadden before the North-Western (U.S.) Electrical Association. The author pointed out that in selecting a transformer for a given customer, the central-station superintendent will too often instal one capable of supplying the total number of lights for which the house is wired. In some cases this cannot be avoided, but in houses wired, say, for 40 to 50 lights, he considers that it will seldom be necessary to put up a transformer any larger than a 30-lighter. The neighbourhood, the size of his family, and their habits relative to the probability of entertainments involving the burning of nearly all the lamps in the house, would all with a moment's consideration determine sufficiently closely what the maximum load would be. The author asks whether it is always necessary to instal a transformer for every individual customer? He states that even the bunching of, say, three moderately large transformers to serve four or five consumers where one or at most two are likely to have a large load at one time and where this comes so seldom as to make it expensive to put up for each of them a transformer capable of taking that load, while a step in the right direction, is seldom good practice; for if the primary fuse of one should blow them out not only does the secondary of that transformer (which is now dead, as far as its capacity to give out current is concerned) become a load upon the other two, but also the load of lamps it formerly carried must now be borne by the others. When this is the case, the fuses of the other two will be likely to blow and the whole arrangement disabled. More than one case has recently come to the notice of the author, showing how in practice the substitution of one large transformer for several smaller ones has worked to the saving in first cost to the station, and in the economy of operation as well. Apart from the advantages of regulation and efficiency, there are other and quite as palpable ones that especially recommend this system. Perhaps first of all comes the saving in the first cost. This plan not only preserves this advantage in first cost of large transformers, but also admits of the use of a very much lower capacity than the aggregate of the lamps wired up. There is a greater saving in the cost of installation and in the cost of repairs. Further than this, the danger from lighting in the primaries is reduced at least in proportion to the number of transformers replaced. These remarks concerned the use of large transformers with secondaries connected on the ordinary two-wire system, using, if desired and the distances are not great, 52-volt lamps; otherwise, 110 volts; but why stop here? The very reason the alternating system was adopted was on account of the saving in copper in the mains and feeders, and this was done by sending a small current to a great distance at a high voltage, knowing that it is only amperage that demands a large cross-section of copper. Now, he asks, why not apply this principle to the secondary wiring as well, using as high a voltage as is permissible in practice? Manifestly, this can be accomplished by running the secondary wiring on the three-wire system having a difference of potential of 220 volts between the outside wires, and using 110-volt lamps. Here, again, is introduced a feature that, added to those above enumerated as being present in the use of large transformers, makes the system of three-wire secondary wiring from transformers the most efficient that modern practice is capable of. The loss in the secondary wiring is here cut down to minimum, as the current is only one-fourth of what it would be with an equal number of lamps of 52 volts and for the same percentage of loss, the actual drop in volts can be doubled. As a consequence the wire for a 220-volt circuit would need to be but $\frac{5}{64}$ of that for a 50-volt circuit. Ordinary transformers can of course be connected in pairs with their 100-volt secondaries in series, and run out on three-wire, but he opines that a still greater saving is secured in using a transformer whose secondaries are so brought out that a three-wire service is obtained directly from the one transformer.

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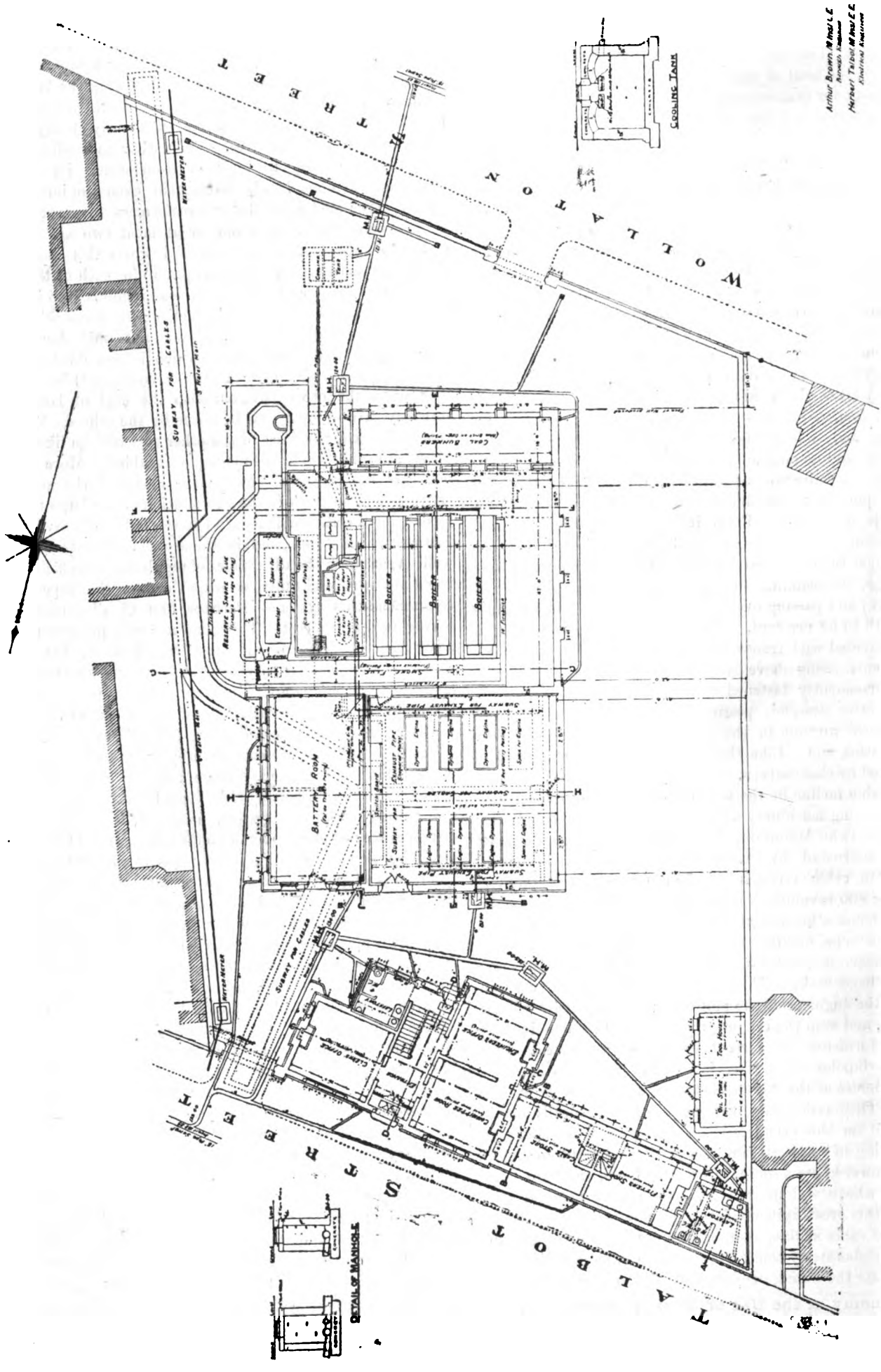
THE NOTTINGHAM MUNICIPAL ELECTRICITY WORKS.



Nottingham Municipal Electric Light Station—Ground Plan.

The history of the electric lighting question in Nottingham is somewhat similar to that in other large boroughs. The consideration of the question was relegated by the Town Council to a special committee, and one of the first

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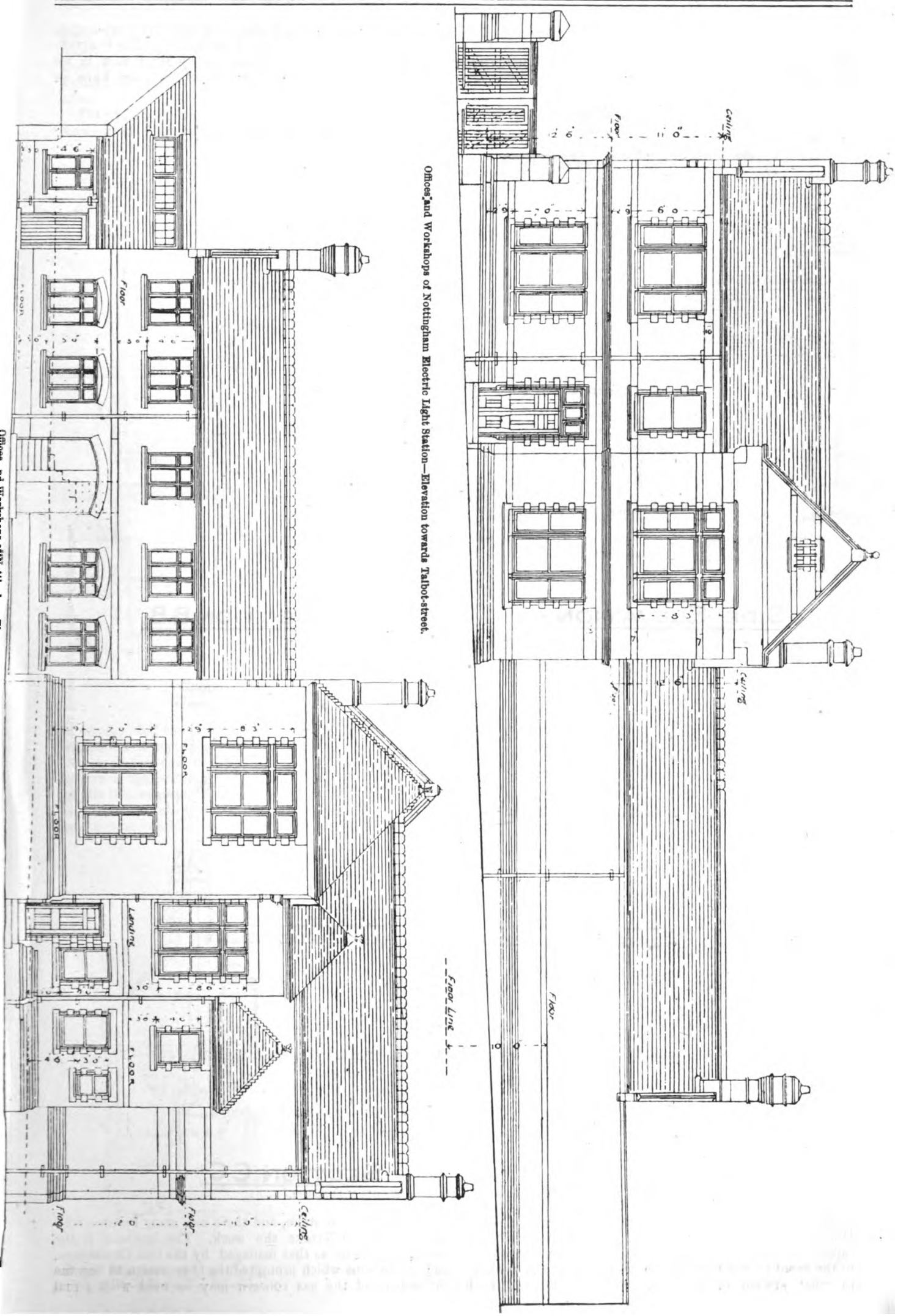

Offices and Workshops of Nottingham Electric Light Station—Elevation towards Talbot-street.

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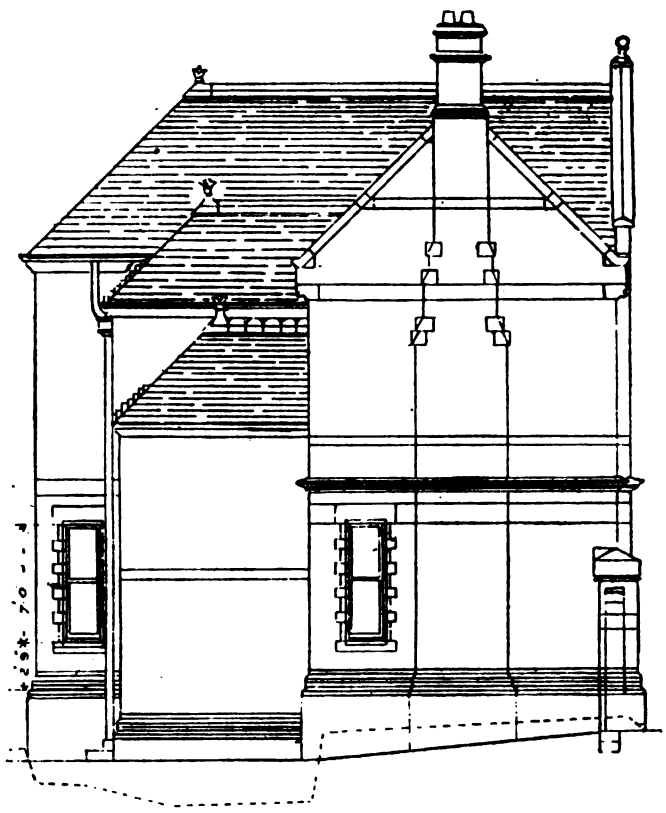
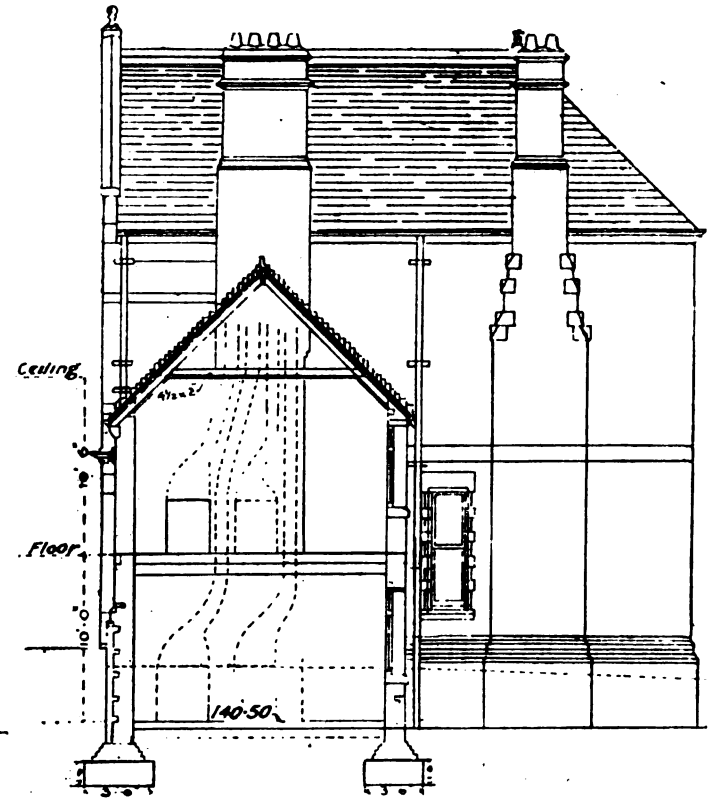
questions which they had to decide was whether they should allow the supply of electricity to be taken in hand by a private company or whether they should undertake the supply themselves.

these gentlemen strongly advocated that the Corporation should undertake the supply of electricity. The Corporation of Nottingham, as pointed out by Mr. Preece in his report, are already the purveyors of gas, and have an

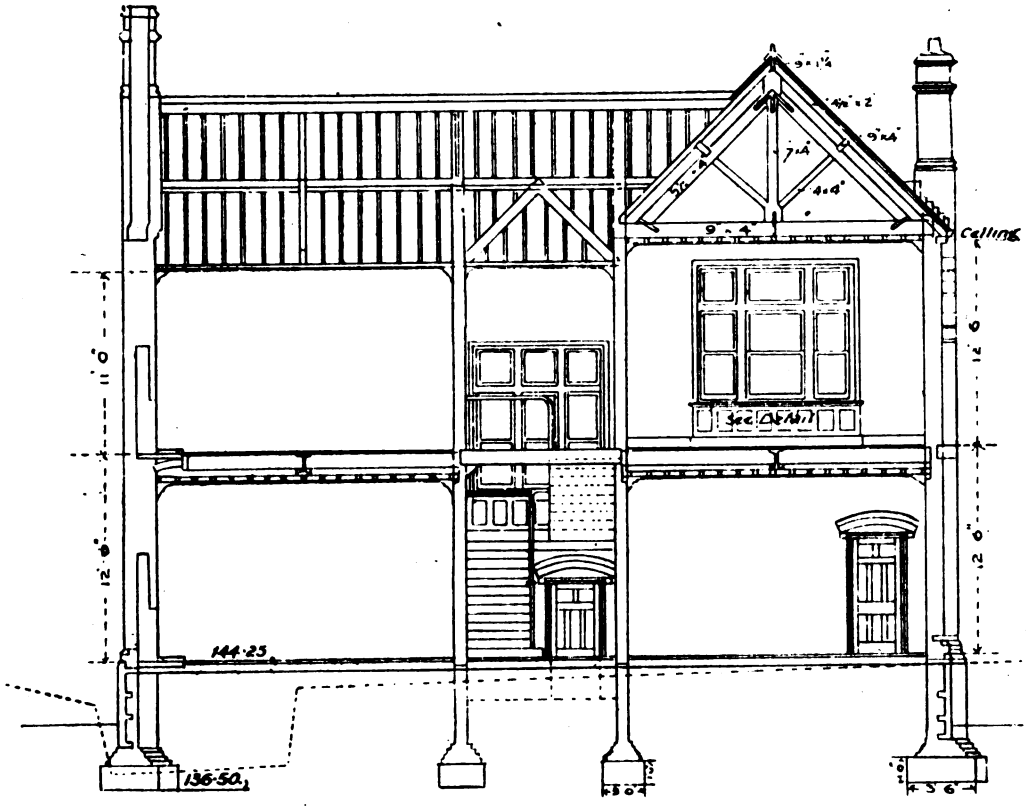


SIDE ELEVATION



SECTION.B.B.

Offices and Workshops of Nottingham Electric Light Station.



SECTION.C.C.

Offices and Workshops of Nottingham Electric Light Station.

The Electric Lighting Committee engaged Dr. John Hopkinson, F.R.S., and Mr. W. H. Preece, F.R.S., to report to them upon the question, and also to advise them in the event of the Corporation undertaking the work, as to what system of supply should be adopted. Both

immense capital at stake, and there are many reasons why they should undertake the work. The business is the same in character as that managed by the Gas Committee, and the reasons which prompted the Corporation to become the owners of the gas concern may be used with equal

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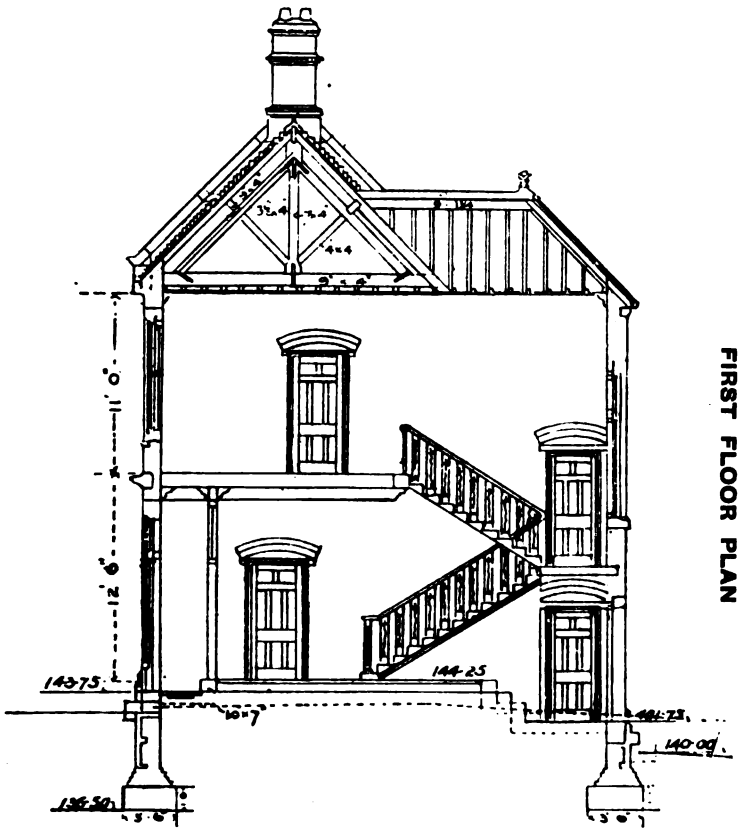
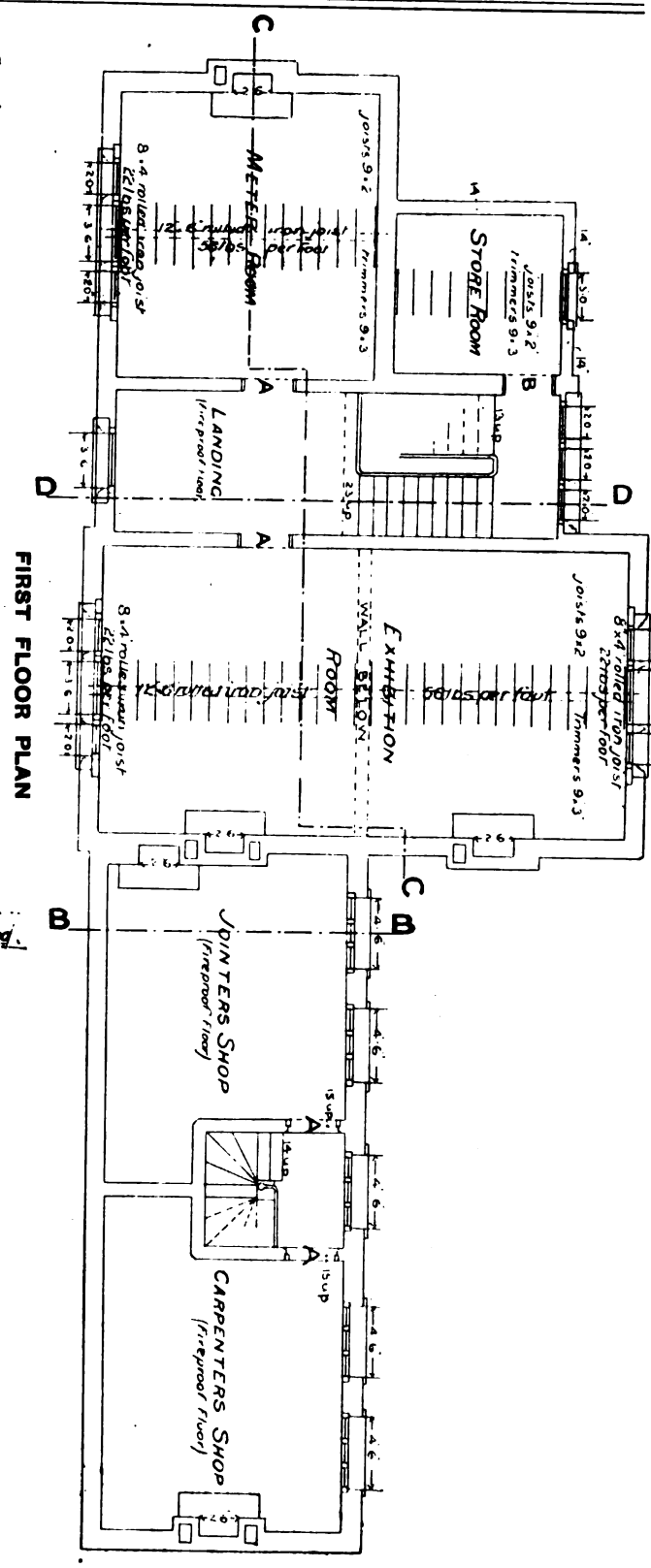
force to decide whether the Corporation or a private company should own the electric lighting concern. The Corporation were advised to adopt the low-pressure continuous-current on the three-wire system for the compulsory area.

The electric lighting order was obtained in the year 1890. The whole of the borough was therein constituted the area

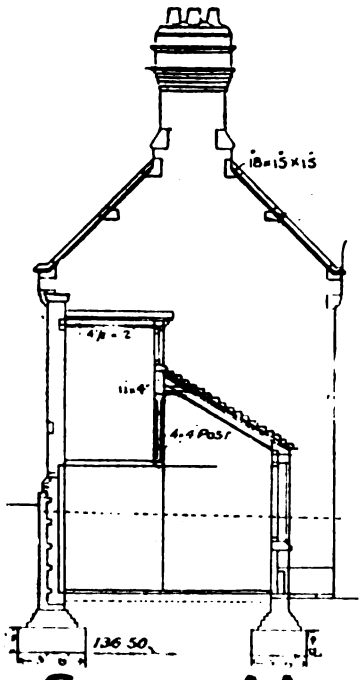


SECTION. D.D.

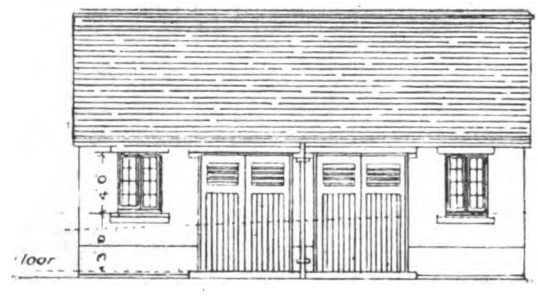
of supply, and the Corporation were according to the order compelled to lay distributing mains in 18 of the principal streets in and near the Market-place, which is the business centre of the borough. After having received the reports of the two experts, the Electric Lighting Committee visited some of the most modern electricity supply stations, both in and out of London, and gained most valuable information.



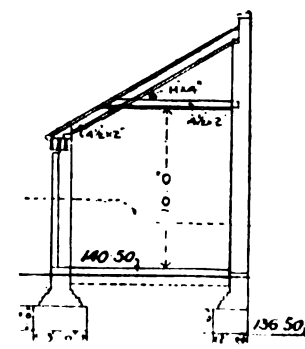
FIRST FLOOR PLAN



SECTION. A.A.



ELEVATION OF STORES



SECTION

Offices and Workshops of Nottingham Electric Light Station.

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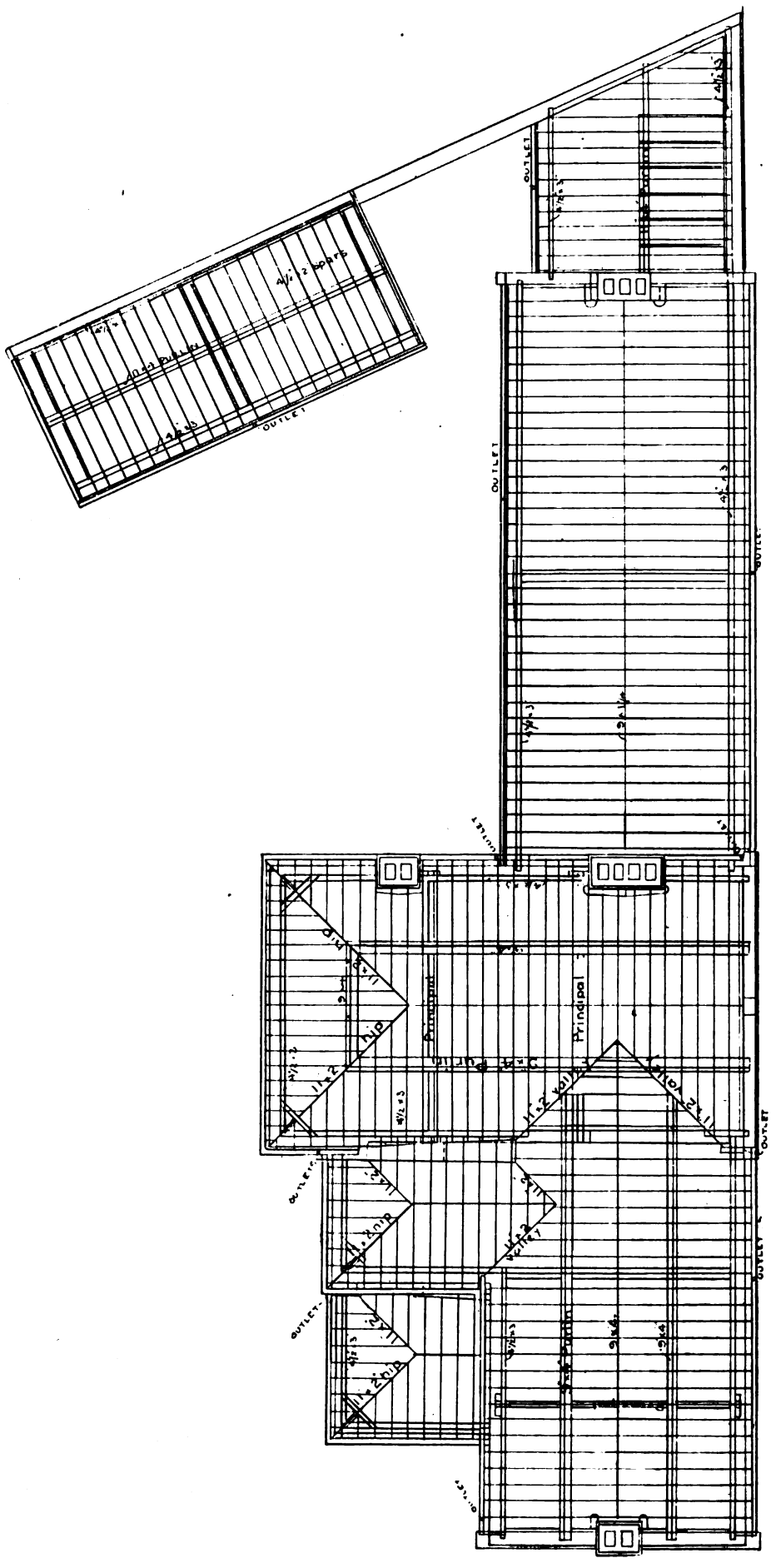
The time had now arrived when it was necessary that an electrical engineer should be appointed, and the committee would recommend should be adopted, and upon the site for the generating station.



ROOF PLAN

Offices and Workshops of Nottingham Electric Light Station.

were fortunate in securing the services of Mr. H. Talbot, M.I.E.E., who immediately after his appointment made a lengthy report to the committee upon the system which he

It was not expected that there would be any demand for the supply of the electric light for some time beyond a radius of three quarters of a mile from the generating

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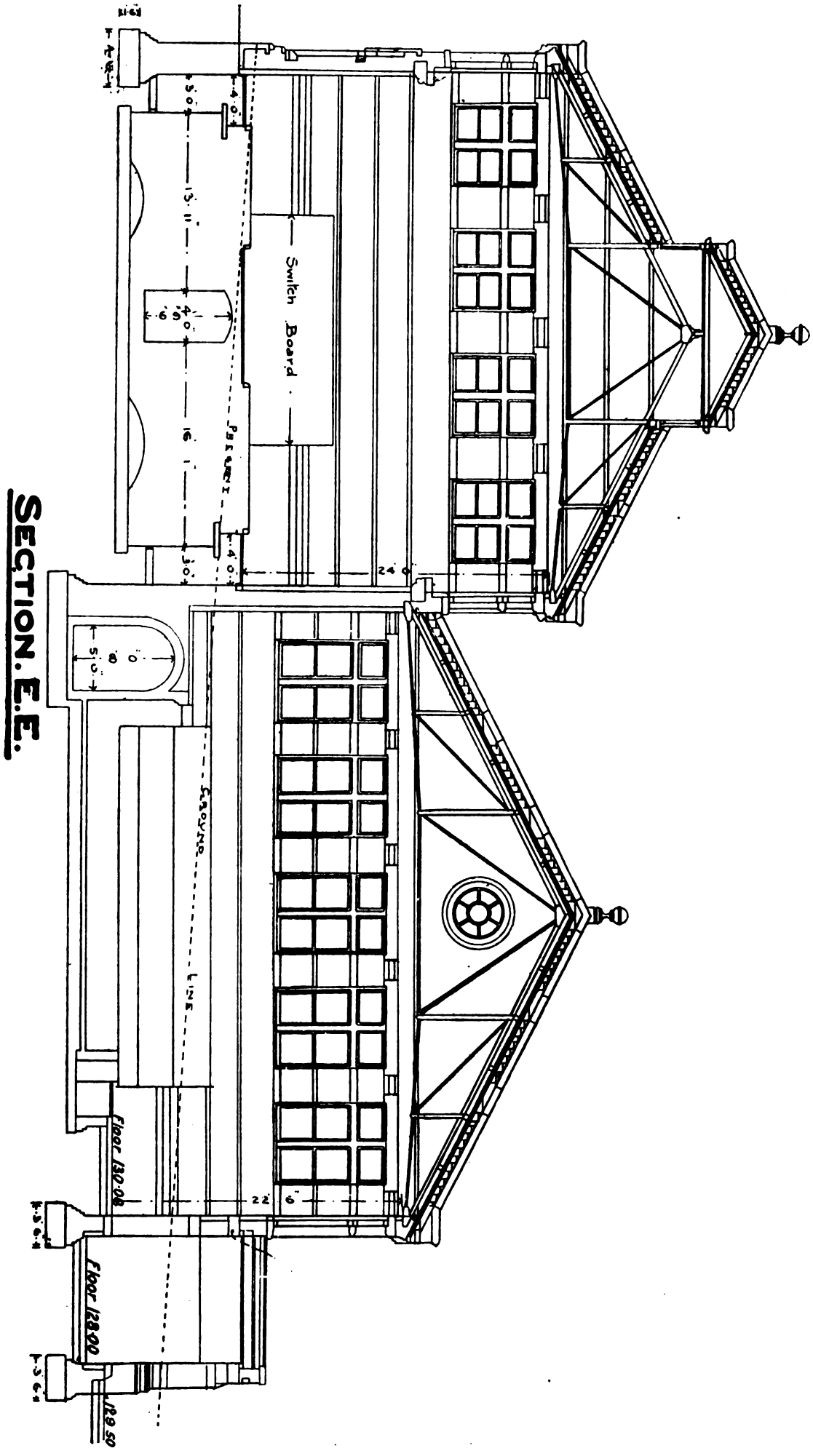

SECTION. E.E.

Nottingham Municipal Electric Light Station—Engine and Boiler Houses.

station, and therefore Mr. Talbot advised that the Corporation should adopt the low-pressure continuous-current three-wire system, especially as this system is suited for the supply of motive power, and it is very probable that there will be

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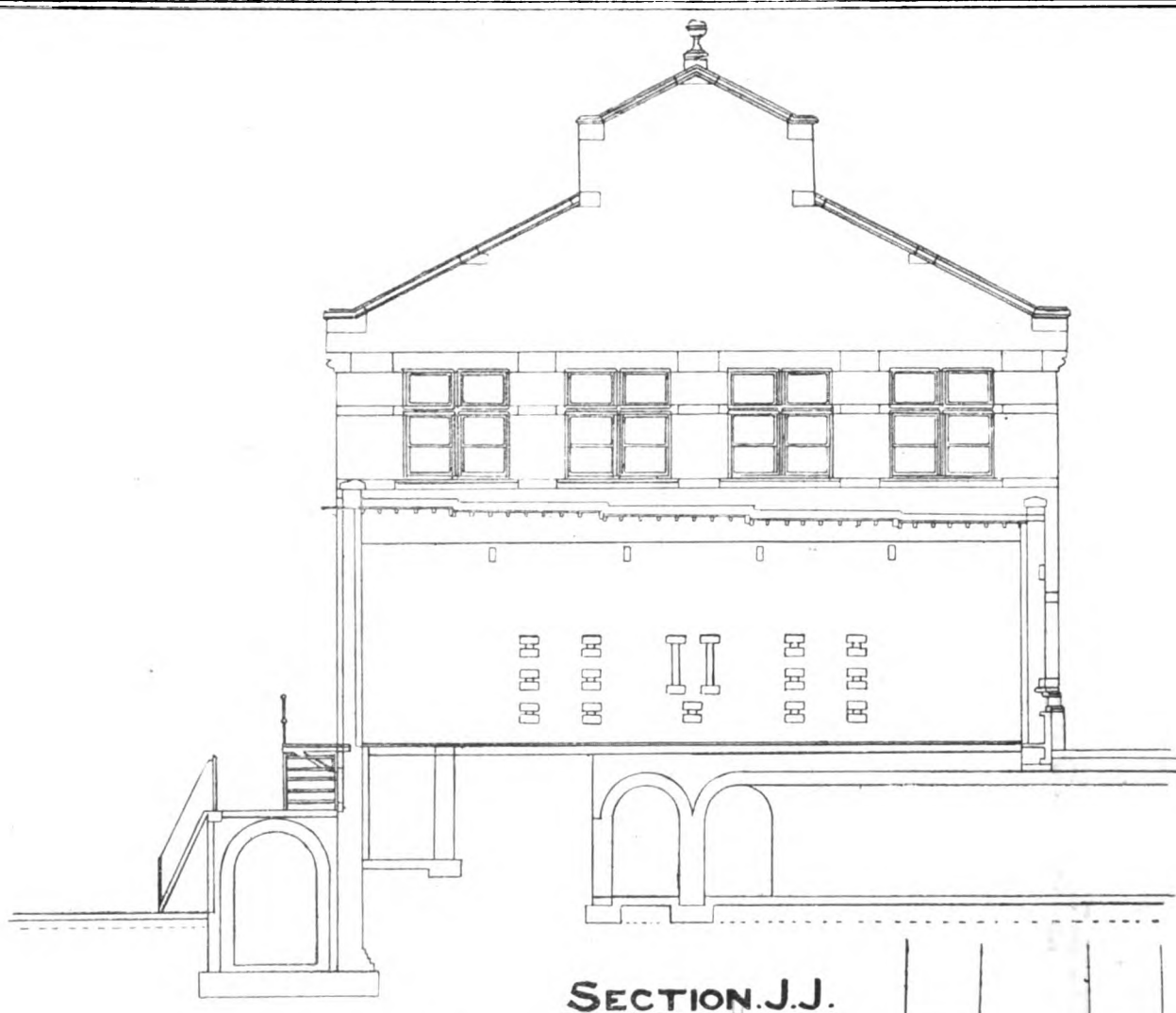

SECTION J.J.

Nottingham Municipal Electric Light Station—Battery Room.

SOUTH ELEVATION OF BOILER ROOM.

Nottingham Municipal Electric Light Station.

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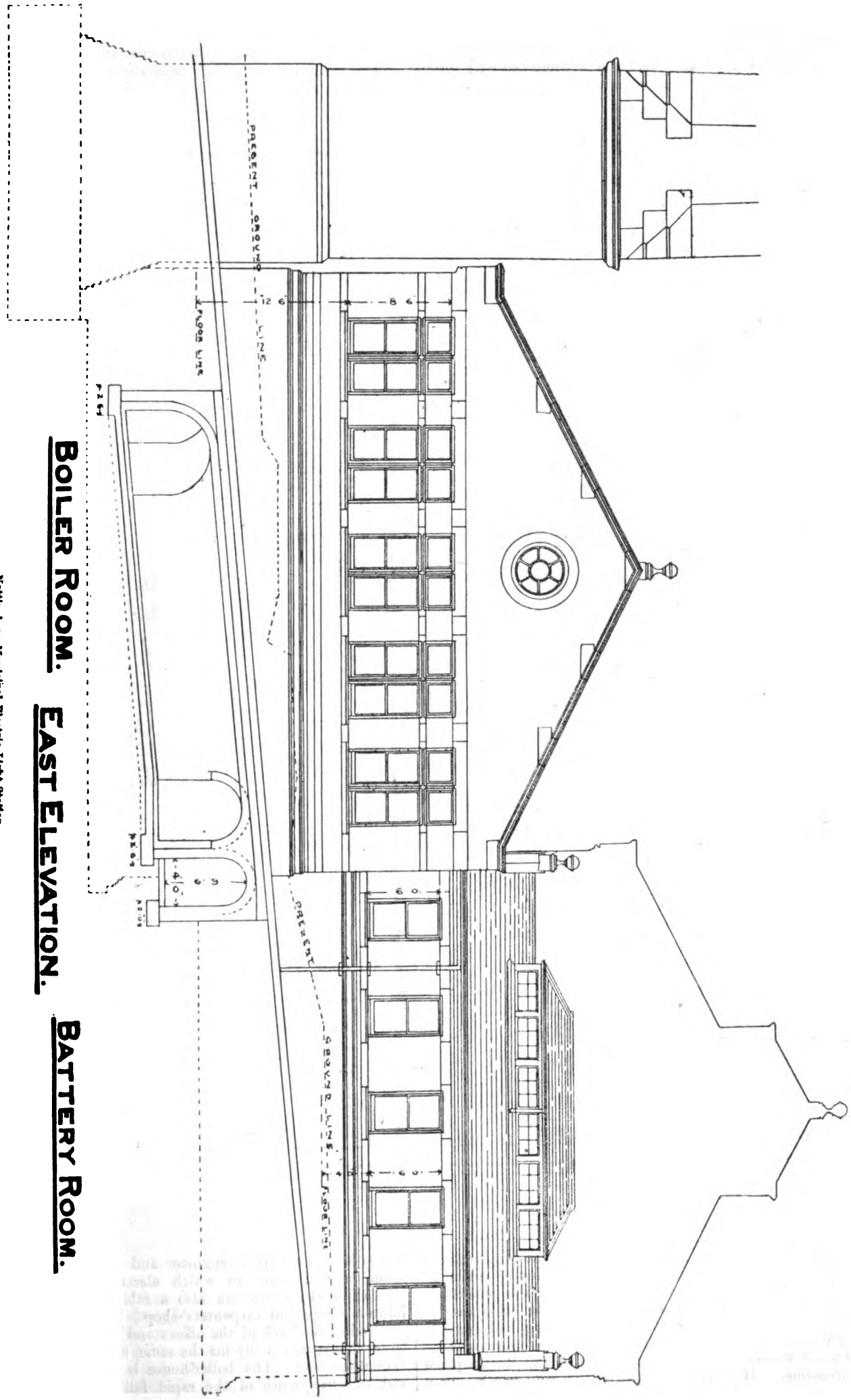

Nottingham Municipal Electric Light Station.

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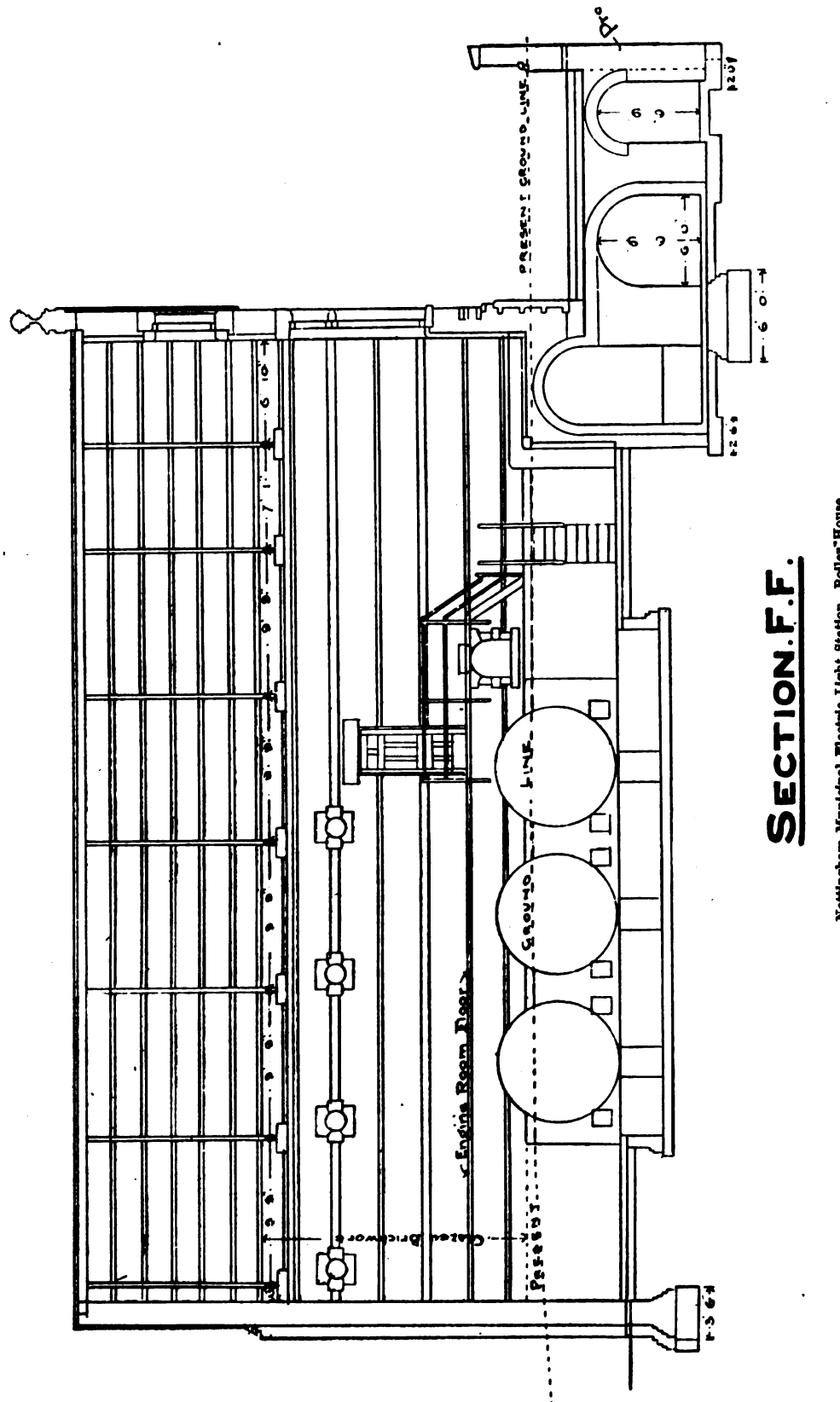
a demand for this in the district near and around the Market-place. As the demand for the light increases, and it is necessary to supply the light beyond the radius in which the low-pressure continuous-current system may be economically worked, there may be combined with this the high-pressure continuous-current system transformed to low pressure by motor generators to meet the requirements of the residential part of the town. Considerable difficulty was experienced in finding a suitable site for the generating station. It was of importance that it should be as near as possible to the centre of the area to be supplied, but the high price of land and property rendered the purchase of a site within the immediate vicinity of the Market-place impossible. However, a site eminently suitable was obtained only 300 yards distant from the Market-place; the area of the site is 2,800 square yards, and it has frontages to Wollaton-street and Talbot-street.

The accompanying illustrations show details of the station buildings. The generating station comprises, firstly, a block of buildings facing Talbot-street, with offices for the electrical engineer and his staff, committee-room, and a room in which electrical appliances can be exhibited; there are also a cable-store, fitters'-shop, jointers' shop, and carpenters' shop. The engine-house is situated at the back of the offices and workshops, and the boiler-house, which adjoins the same, has its entrance from Wollaton-street. The boiler-house is 63ft. 9in. by 47ft., and, in consequence of the rapid fall in the ground from



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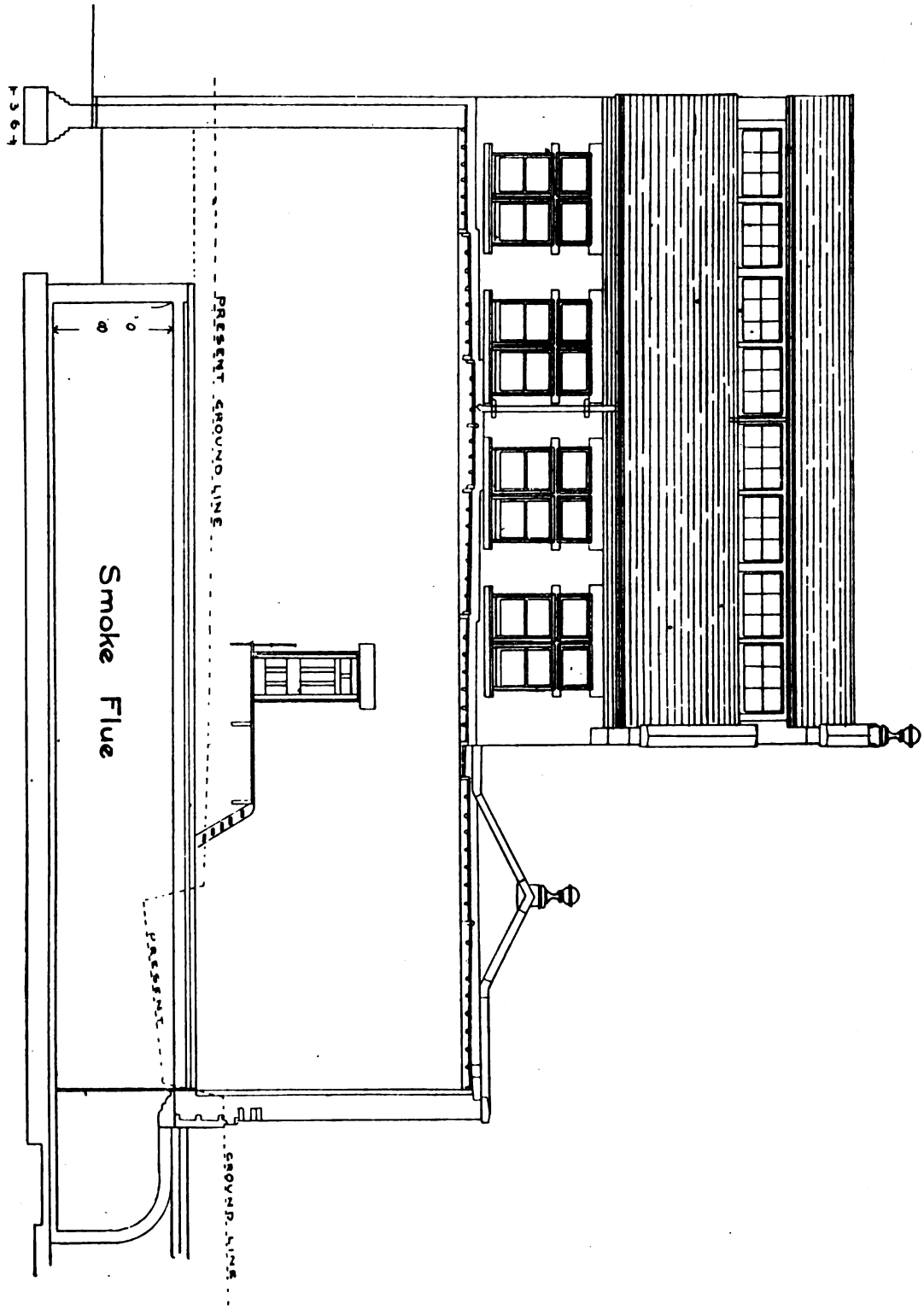
north to south, the floor of the boiler-house is 10ft. below the floor of the engine-house. There will be four boilers of the Lancashire type, 28ft. long by 7ft. diameter; three of these boilers are now on order from Mr. E. Danks, of the Oldbury Boiler Works, near Birmingham. In the main flue is fixed a Green's fuel economiser of



SECTION C.C.

Nottingham Municipal Electric Light Station—Boiler House.

128 tubes, and a Berryman feed-water heater is being supplied by Messrs. Jos. Wright and Co., of Tipton. The same firm is also supplying two of Pearn's automatic quadruple-acting vertical flywheel pumps for feeding the boilers. The feed-pipes will be arranged so that the feed-water can be passed either through the economiser or heater separately, or through the two in series. The whole of the steam-pipes are being supplied by Messrs. Lloyd and Lloyd, of the Albion Tube Works, Birmingham, and will be of mild steel throughout; the branches and flanges will be electrically welded on solid. The steam-main in engine-room is being constructed in the form of a ring, and will be fed at different points from the main in the boiler-room. Hopkinson's patent parallel slide valves are being used throughout, and one is placed in the main steam-pipe between each boiler and each engine. The main steam-pipes are 8in. bore, $\frac{5}{16}$in. steel, with flanges 15in. diameter and $1\frac{1}{4}$in. thick. The boiler pipes and valves are 6in. bore, $\frac{5}{16}$in. thick, and the flanges 12in. diameter and $1\frac{1}{4}$in. thick.

(To be continued.)

The John Scott Legacy Premium and Medal.—The John Scott legacy premium and medal, awarded by the city of Philadelphia upon recommendation of the Franklin Institute, has been granted to Mr. Nelson W Perry for his method of series electric traction.

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THE
ELECTRICAL ENGINEER.

Published every Friday.
Price Threepence; Post Free, Threepence Halfpenny.

Editorial and Publishing Offices:
39-140, SALISBURY COURT, FLEET STREET,
LONDON, E.C.

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TO CORRESPONDENTS.

All Rights Reserved. Secretaries and Managers of Companies are invited to furnish notice of Meetings, Issue of New Shares, Installations, Contracts, and any information connected with Electrical Engineering which may be interesting to our readers. Inventors are informed that any account of their inventions submitted to us will receive our best consideration.

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THE BOARD OF TRADE ON ELECTRIC TRACTION.

On Wednesday last there was held at Richmond-terrace, Whitehall, a conference of those more especially interested in the development or the converse of electric traction, under the auspices of the Board of Trade, when the draft rules prepared by the Board for carrying out and operating electric lines were brought up for discussion and amendment where necessary in the general public interest. So important, however, are the matters involved, that the meeting had to be adjourned until this (Friday) morning in order to complete such full discussion of them as proved desirable, and we must therefore suspend final judgment as to the position and prospects of electric traction, now at last to be clearly defined, though we hope not excessively limited.

In thus bringing the whole question to a final focus—after months of evidence and argument before parliamentary committees, joint and separate; after careful consideration of probable effects upon their interests by the tramway, railway, telegraph, telephone, gas, and water companies (who have each and all claimed with justice to be heard on the subject); after energetic movement on the part of municipalities either now or in the future concerned in the ownership of such undertakings—the Board of Trade is, in the first place, deserving of hearty congratulation upon the exceedingly fair and open way in which criticisms have been invited and amendments (proved reasonable) readily adopted. Such a meed of praise becomes the more due when the true position of the Board is fully realised, and its action better understood. The contrast between the present prospects of electric traction and those of electric lighting when the Bill of 1882 was about to become law, cannot fail to be very striking to those who trace the history of the latter, and are able now to gauge the effect of the rules just compiled in their accepted form; not only can one still express entire confidence in the fairness and want of bias or prejudice in this department of State, but, what is much more to the point, a far greater degree of wisdom and foresight has been shown in this matter—proof positive that the experience already gained is now of service under new conditions.

When it is remembered that the Board of Trade, as a Government executive office, has been in the delicate position of enunciating rules for the conduct of one industry—viz., that of electric traction—which must inevitably affect in a more or less serious manner another industry—that of supplying telephonic communication—which may at an early date become a Government undertaking, the fairness, not of the draft rules themselves, but of the Board in accepting amendments, almost causes one to wonder whether it is because in the somewhat distant future the tramways themselves may be "nationalised," and become a department of State property on an equal footing with telegraphs and telephones. Nowadays, one never knows what political developments may not be in store for us with so great a spread of municipal feeling.

Returning, however, to the draft rules themselves, and the amendments proposed by one party

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and another of those most interested, it is not so easy to acknowledge the presence of absolute fairness. On many points the Board of Trade proposals actually traverse in a most fundamental fashion the spirit of the conclusions reached by the Joint Parliamentary Committee last year—notably so in Rule 14, the last dealt with at Wednesday's conference. We are glad, however, to see that the position thus assumed by the Board in requiring the tramway company to "avoid injurious interference with any existing wires" has been so far modified that the undertakers of any electric traction scheme will not be called upon to do more than "take all reasonable precautions" against injuriously affecting wires now erected. Apparently the decision as to what is "reasonable" or not is left with the Board of Trade: this is to be regretted in some respects, for although Government inspection may be absolutely impartial, it cannot be always consistent, whilst it must be arbitrary.

Amongst those foremost in suggesting practical alterations and amendments of the rules from an electrical point of view have been the Institution of Electrical Engineers, the Electrical Trades Section of the London Chamber of Commerce, the Association of Municipal Corporations (based on a report of the whole question submitted by Dr. Fleming), and the Imperial Tramways Company, Limited (an interest which has powers and proposals for electric lines of considerable importance and magnitude); and it is pleasing to see that in most instances their suggestions have been adopted. The National Telephone Company has not in any way sought to go behind the Joint Committee's report, although some of its proposed amendments are of too severe a character for an industry struggling to establish itself. Possibly the anticipation of Government purchase may have caused the telephone interests to feel secure of a position at least equal to any that electric traction might attain. Strong criticism is, however, deserved by the proposals made on behalf of the associated railway companies, and although these are only set down for discussion at the meeting to-day, we cannot refrain from saying that they appear to us extremely ill-considered and badly drafted. The first one (additional No. 2) is no proposal at all, but a mere statement. The second is unnecessary, being provided for in an amendment due to the Institution of Electrical Engineers. The third is absolutely impossible—seeking, indeed, to make unlawful any leakage of current whatever to earth. The fourth concerns only the tramway companies themselves, and has no effect at all upon the railway systems; whilst the fifth is absolutely opposed to the Joint Committee's report. Admittedly, the question of electric tramway leakage currents affecting railroad signals is of enormous importance, but the matter may be summed up in Major-General Webber's words, "the protection of block signals lies wholly in the hands of the railway companies themselves." If they are affected in the same way and to the same extent as the telephone systems, they ought surely to be contented with the same latitude allowed to the latter.

Finally, the Gaslight and Coke Company assumes a similar position of "injured innocence," and because its mains are leaky, desires to make someone else suffer rather than put its own house in order. Accordingly, the right to obtain damages against tramway companies (also with leaky mains) is sought for, just as in the old fable the sieve howled at the needle for being so imperfect as to have a hole in it. We are glad to see that Sir Courtenay Boyle very properly threw the onus of such indemnity upon the shoulders of Parliament, where it rightly belongs, instead of the Board of Trade.

REVIEWS.

Electric Waves; being Researches on the Propagation of Electric Action with Finite Velocity through Space. By Dr. HEINRICH HERTZ. Authorised English translation by D. E. JONES, B.Sc., with a preface by LORD KELVIN, P.R.S. London: Macmillan, 1893.

The appearance of this volume, following so closely upon the untimely death of Prof. Hertz, only emphasises the irretrievable loss which science has thereby suffered. At the same time it serves to remind us that one part of Hertz's work was really finished, and that he regarded the identity of electrical and optical radiations as a completely established fact. This thought alone can console us when we reflect what Hertz might have accomplished had he lived.

In the history of a theory four consecutive stages can generally be traced, through the first three of which the ether theory has already passed. The first stage consists in the accumulation of experimental facts which have apparently no connection with each other, except that they are phenomena exhibited by the same body (as, for example, the electric conductivity of solids and their opacity to light), or that they refer to similar results produced by different causes, as in the case of electrical and gravitational attractions. The ether theory of electrical actions was in this stage when Faraday appeared; the theory of gravitation has not yet passed beyond it. As the facts increase in number and new relations between them are gradually discovered we are led to the formulation of a theory, tentatively at first to account for a few phenomena; afterwards, by the aid of mathematical generalisations, we ultimately arrive at a complete explanation of all the facts. The work of Faraday was the formulation of the ether theory; to Maxwell belongs the mathematical development of it.

The task of these two philosophers was, however, rendered much more difficult because a theory already existed, that of action at a distance, by which nearly all the observed facts could be accounted for. The history of this theory is well told by Lord Kelvin in the preface to the present volume. Faraday and Maxwell had not only to combat the notion of direct exertion of force across empty space, but were compelled to produce convincing evidence of the existence of a medium for its propagation before their theory could be considered complete. This necessitated either the proof that a finite time was required for the propagation of electric disturbances (direct action at a distance requiring no finite time), or else the properties of the medium must be identical with those of the luminiferous ether. To fill space with two distinct ethers was quite as repugnant to their minds as to leave it absolutely void. Faraday himself found that the plane of vibration of light was rotated by a magnetic field, but he died without making further progress. Maxwell showed Faraday's observations to be in strict accordance with the new theory; he also worked out the theory of electric waves, and proved that the reciprocal of the square of their velocity of propagation through any substance must be equal to the product of the magnetic permeability and the specific inductive capacity of that substance. Experiments showed that the inverse square root of the latter product was equal

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to the velocity of light, and thus everything pointed to an identity in the mode of transmitting the two kinds of waves, although so far the evidence was entirely indirect. So ended the second chapter in the history of the theory.

The experimental treatment of electric disturbances, based upon the happy discovery of electric resonance and the interference of electric waves, has formed the life work of Hertz, and is recorded in historical order in the book before us. The author has enriched it by the insertion of an introductory article explaining how he was led to carry out the experiments described. It is impossible to select any one paper of the series as being of more importance than the rest; perhaps for general interest that on "Electric Radiation" (p. 172), will have pre-eminence, as it describes the reflection, refraction, polarisation, and interference of electric waves just according to the manner of light waves, and leaves no room for doubt that the two are absolutely identical except in wave lengrh.

The ether theory of electricity and light has thus passed through the three stages of isolated facts, growth into mathematical form, and proof by crucial experiment. It remains to be seen whether it can survive the fourth stage, that of proving itself consistent with other physical theories. Mr. Glazebrook has already pointed out (British Association Address to Section A, 1893) that the disturbance of the ether assumed in light vibrations is a purely mechanical one—in fact, the whole theory of light vibrations is purely mechanical; while for electric waves the disturbance consists of a displacement of electricity, and its electrostatic and electromagnetic effects are propagated with the velocity of light. Dr. Larmor has shown a way out of the difficulty by postulating that dielectric polarisation is a mechanical strain in the ether, the strain being of a rotational character, inasmuch as it always occurs in a closed curve. This seems a possible explanation, but it must be remembered that the ether has yet other functions to perform. We have still to discover what modifications it undergoes in the neighbourhood of gross matter, a vast subject of which the fringe only has been touched. Indeed, we have no evidence that matter itself is not a modification of the ether. Further, it is as yet quite impossible to answer the questions whether we can ascribe to the same medium the power of conveying gravitational stresses and the stresses exerted by mind on mind, and possibly on matter.

English readers will be glad that Mr. Jones has accomplished the task of translating Hertz's work from the original German, and that the English edition is enriched by a preface from the pen of Lord Kelvin. The translator has done his work well, and the simple straightforward descriptions of experiment and deduction which recall the style of Faraday's writings, have not suffered by being expressed in a foreign tongue. One or two new terms have been invented which we hope may become general. For instance, the combination distance-force is used to express a force directly exerted through space on a distant particle (*Fernkraft*). The Germans have been greatly ridiculed for coining compound words, but when these come to be translated one begins rather to admire the perfection of a language which can concentrate the meaning of a whole sentence into a few syllables. At the same time they prove very troublesome to a translator, and they sometimes cause the translated sentence to lose all the neatness and simplicity which it possessed in the original.

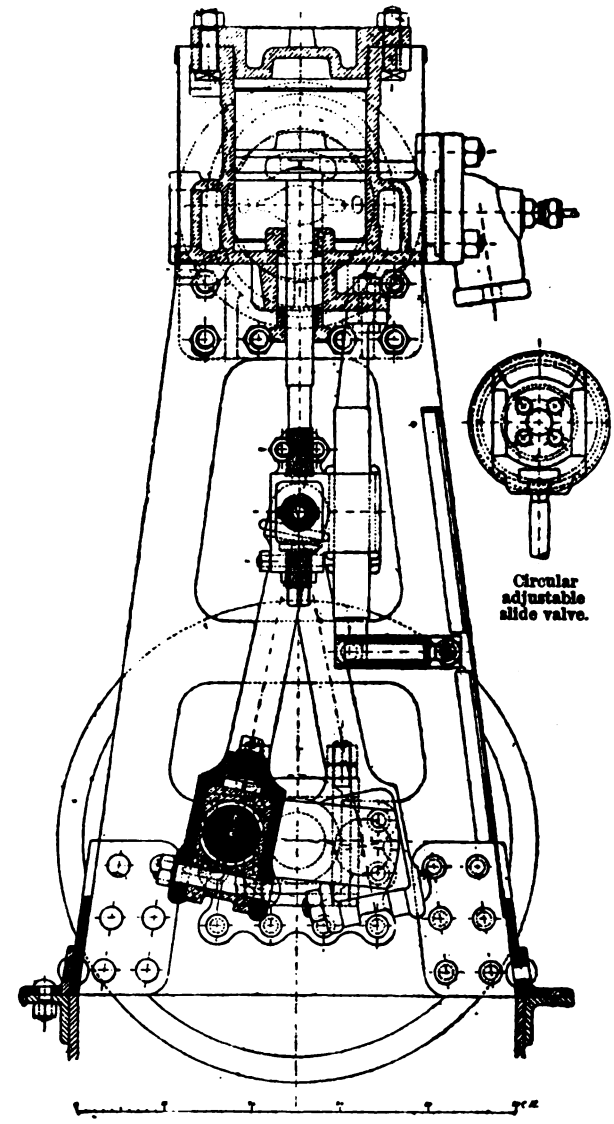
JAMES L. HOWARD.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

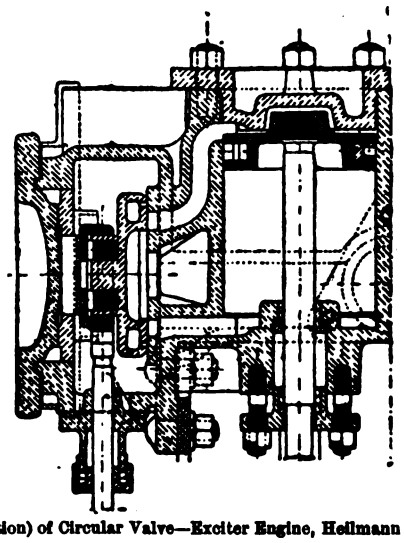
THE HEILMANN ELECTRIC LOCOMOTIVE.

SIR,—There are one or two misprints in the description of the above, published under my name in your issue of last Friday, which I would like to see corrected, if possible. In the first place, the illustration of one of the motors does not represent, as stated, a vertical section *along*, but *across*, the axle. This would be, perhaps, obvious to the reader, but was not altogether clear owing to the motor being shown partly in section and partly in elevation. Secondly, Messrs. Brown, Boveri, and Co. are established at *Baden*, in Switzerland, not at Basle, which is some distance away.



Sectional Elevation—High-speed Exciter Engine, Heilmann Locomotive

Finally, the gross weight of the locomotive, stated to be 42 tons, is nearer three times that amount. This, however, is not an error of primary importance, as the weight of any experimental engine—the first of its kind—is always nearly double what it may be worked down to with a little experience.



Side View (Section) of Circular Valve—Exciter Engine, Heilmann Locomotive.

Whilst writing you on the subject, it may be of interest to draw more special attention to the very neat form of high-speed vertical engine employed to drive the exciter

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dynamo. The valve arrangement, as may be seen from the accompanying illustrations, is of peculiar pattern, having a circular shape, and being practically self-adjusting for surface wear.

This engine has two cylinders side by side, each 6in. diameter, with 6in. stroke; the cranks are set at 180deg. apart; the speed, as stated, is 300 revolutions per minute. For an open engine, with no special arrangements for lubrication, etc., the running at this speed appears to be all that one could wish. Of course the output is small—not more than about 16 kilowatts—and doubtless the steam consumption would be heavy even with the cut off at 50 per cent. A centrifugal governor on the flywheel serves otherwise to regulate the speed.—Yours, etc.,

FRANK B. LEA.

PRACTICAL INSTRUMENTS FOR THE MEASUREMENT OF ELECTRICITY.

BY J. T. NIBLETT AND J. T. EWEN, B.SC.

XVII.

(Continued from page 71.)

RESISTANCE, *continued.*

Wheatstone's Bridge with Earth Return.—When it is desired to measure the resistance of any conductor, such as a telegraph wire or cable, for instance, where it would be impracticable to connect up both ends to an ordinary Wheatstone's bridge, advantage is taken of the earth as a conductor, and connection is established through it. Its great size renders the resistance of the earth practically nil, and therefore its potential at all places may be taken as the same. Potential, like temperature, being a merely relative term, its zero—as has been done in the case of temperature—may be selected arbitrarily; and it is found most convenient to take the potential of the earth as zero, so that potentials higher than that of the earth are termed positive, and those lower, negative. Thus if any point in a circuit be directly connected with the earth, the potential of that point is at once reduced to zero, provided the earth connection is made without any sensible resistance—an important consideration.

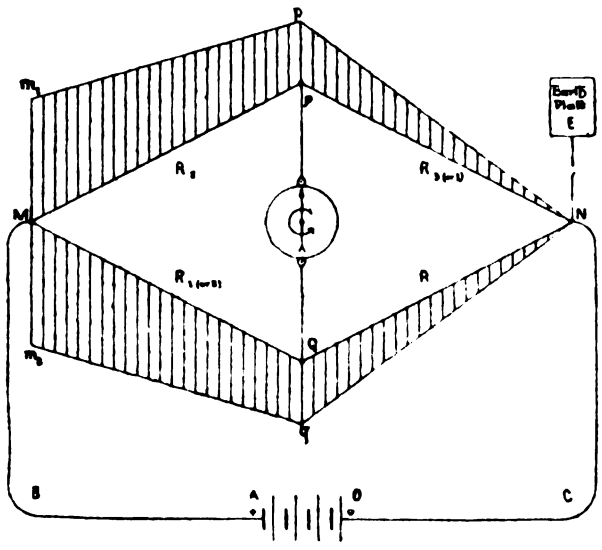

FIG. 42.—Wheatstone's Bridge Circuit (closed), with Earth Connection.

To illustrate the principle involved in the application of an earth return to a Wheatstone's bridge, let A B M $\frac{P}{Q}$ N C D, in Fig. 42, be the divided circuit, in which A and D are the positive and negative poles of the battery or other current generator, and M P N and M Q N are the two arms of the bridge, with a galvanometer interposed in the usual way between the two points P and Q. M P and P N respectively represent the ratios R_2 and R_3, M Q is the known variable resistance R_1, and Q N is the resistance being measured, R. Or, since R is $= \frac{R_1 R_3}{R_2}$, we may interchange the positions of R_1 and R_3 as indicated in the figure, so that M P and M Q represent the ratios, and P N the known variable resistance, Q N representing, as before, the unknown resistance. This is indeed the most usual arrangement in testing sets, one pole of the battery being generally connected between the two ratios R_2 and R_3.

Let now the point N be connected to earth by means of the earth-plate E, as shown. Then the potential at N and at the negative pole, D, of the battery at once become zero, and the diagrams of potential for the two arms of the bridge will be of the type shown by the two vertically-shaded figures. In these figures the potential at any point in M P or P N is represented by the vertical height of the diagram above that point, while potentials of points in M Q and Q N are measured vertically downwards. Thus the potential of M is represented by Mm_1 or Mm_2, which, of course, are equal; the potential at P is represented by Pp, and at Q by Qq, while at N the potential is zero. The difference of potential between any two points is represented by the difference in height of the figure or figures at the two points. It will be seen that the operation of measuring the value of R is in nowise altered by the introduction of the earth-plate at N, and consists, as before, in so altering the relative values of R_1, R_2, and R_3, that the heights Pp and Qq of the potential diagrams at P and Q are exactly equal, in which case the galvanometer needle will show no deflection, and we shall have, as before,

$$R = R_1 \times \frac{R_3}{R_2}.$$

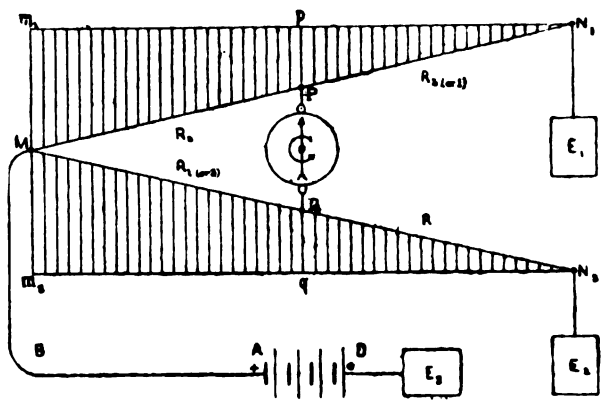

FIG. 43.—Wheatstone's Bridge Circuit (opened), with Earth Connections.

But since the potential of the earth is the same at all places, as we have already seen, the conditions of the test will not be altered, although the three conductors which are shown meeting at N in Fig. 42—namely, R_3 (or 1), R, and the negative pole, D, of the battery—are all separated, as illustrated in Fig. 43, provided each of them is efficiently connected to earth as indicated. The diagrams of potential will be represented by the vertically-shaded figures shown in Fig. 43, which are precisely similar in character to those in Fig. 42, and the galvanometer will show no deflection when the heights Pp and Qq are equal as before, in which case we shall again have

$$R = R_1 \times \frac{R_3}{R_2}.$$

In practice it is usual to make one earth-plate serve for connecting to both N_1 and the battery pole D, thus fulfilling the functions of E_1 and E_3; while N_2, the further end of the cable or wire under test, is generally at a considerable distance, and is connected to a second earth-plate, E_2.

(To be continued.)

THE THEORY AND DESIGN OF THE CLOSED-COIL CONSTANT-CURRENT DYNAMO.*

BY HENRY S. CARHART.

(Concluded from page 176.)

Quoting again from Prof. Ryan: "The air-gap is made of such a depth that the ampere-turns required to set up the magnetisation through the armature, without current,

* Paper read before the Franklin Institute, December 26, 1893.

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and for the production of the highest E.M.F. that the machine will be called on to give, shall be a little more than the armature ampere-turns when it furnishes its normal current. Then as long as the brushes are kept under the pole faces, the non-sparking point will be wherever the brushes are placed. This will be the case whether the armature is or is not saturated." Again: "The impressed field ampere-turns are in excess of the armature ampere-turns by that amount which is just sufficient to produce a weak positive field that will reverse the current in the coil when its terminal bars at the commutator pass under the brush." This latter statement appears to be borne out by the data given, but the machine experimented upon was one giving a maximum of only 35 volts and 22 amperes, and its performance can scarcely be considered a sufficient guide for the design of machines required to furnish several thousand volts and a current of from 9·5 to 10 amperes. Again, I have known a 40-light machine converted into a 50-light without any change in the field whatever. The armature either contained more iron, or was wound with a larger number of turns of wire. Both methods have been followed without effect on the sparking. The first method leaves the armature ampere-turns the same; the second increases them 25 per cent. If the relation pointed out by Prof. Ryan holds in the first armature, it cannot also hold in the second with such a material increase in armature-turns.

Further, if this relation does hold, there still remains unanswered the question of relative cross-section of iron in armature and field. Shall the core of the armature be saturated or not? Mr. Esson says that 17,000 lines per square centimetre is the best practice in England for constant-potential machines.

I know of one constant-current machine in which the armature core is forced well up toward the highest saturation obtainable in a dynamo machine. It is able to produce very high E.M.F., but it does not govern sparklessly by means of a single pair of brushes. Two other types of machine of which I have data work with about 11,000 lines per square centimetre in the armature. In both of these recent changes are along the line of increasing iron and decreasing copper in the armature. I have explicitly advised the use of more iron in the armature for two years. One manufacturer recently told me that he is now following my advice with most gratifying results. With the same number of turns on the armature the output is greatly increased. To what extent the iron in the armature can be increased is an open question. It has now been carried beyond a cross-section equal to 75 per cent. of the wrought iron in the field cores. If increased cross-section of the core introduces sparking, this can be avoided by increasing the number of bars on the commutator, so as to decrease the self-induction in the section under short-circuit by the brush. Indeed, if the output is kept the same, increase of iron decreases turns of wire, and to that extent decreases self-induction. In a machine with two pairs of brushes, the effect is to diminish the angular embrace of each pair.

It is interesting to compare two machines of almost exactly the same capacity, but differing widely in relative core section and armature-turns. Let the two machines be represented by A and B. The data of the two are given in the following table:

Machine.	Total volts.	Revs. per min.	Segments in commutator.	Turns per segment.	Total turns.	Cross-section of iron, sq. in.	Lines per sq. in.
A.....	2,900	1,000	132	36	4,752	26·5	70,800
B.....	2,800	875	120	72	8,640	14·0	79,000

The maximum number of lines of force running through the armature of the A machine is 3,650,000; of the B machine, 2,213,000. The two machines are designed for the same current of a little under 10 amperes. The ratio of the ampere-turns on the armatures of the two is nearly inversely as the cross-section of their iron cores. The ampere-turns on the B armature is 82 per cent. greater than on the A armature. It is not probable that the field ampere-turns on B is 82 per cent. in excess of those on A. Unfortunately those particular data are lacking, but the magnetic circuit of A is quite as good as that of B. It does not appear at all probable, therefore, that Prof. Ryan's rule applies to both machines. It is gratifying to our national pride that American designers have successfully carried the Gramme ring constant-current dynamo to an output far beyond what some foreign electricians with more theory and less practice in this direction still declare to be impracticable. The writer of a series of articles in the London *Electrical Review* says: "Beyond about 1,000 volts it is found, in general, to be impracticable to work a closed-coil armature, for either there will be a wasteful lead, or there will be vicious sparking under the brushes, or the current will flash from strip to strip, and will destroy the commutator. . . . . It seems more than probable that machines of this kind will not stand any serious alteration of load if worked at higher voltages, owing to the great range of lead which would be required, and the consequent sparking and flashing over." Again he says: "There is of necessity a large armature reaction in certain forms of arc light machines, and when this is the case, the brushes would require to be shifted right into the centre of the pole arc before sparking would cease, if there were very many turns on each section. The wastefulness of this practice consists in the large number of back-turns and cross-turns which it involves." But in the face of such declarations as these, a large number of American machines are now running at an output of 9·6 amperes, and from 5,000 to 10,000 volts. A very considerable number of closed-coil Gramme rings, giving 5,000 volts, are in actual use without breakdown and without any of the fatal drawbacks predicted by the writer quoted.

The design of closed-coil Gramme rings for high-potential arc lighting has thus far been limited to the two-pole type of field magnet. This involves the maintenance of higher speeds than engineers find desirable. The conditions of present practice and the requirements for the immediate future demand a new departure in this class of dynamo design. All indications point toward a multipolar machine of about 50 kilowatts capacity and slow speed. The armature will contain a liberal amount of iron, much larger than would be found desirable for constant-potential machines. Such a dynamo is already in demand, and it will find an immediate field for the lighting of large cities.

INSTITUTION OF ELECTRICAL ENGINEERS, Feb. 22.

Mr. Alex. Siemens, President, in the chair.

At last night's meeting of the Institution the following candidates were balloted for:

Foreign Member.—Knud Bryn, Central Telephone Station, Christiania.

Members.—Benjamin Walter Deakin, 2, Raeburn-street, The Avenue, Brixton, S.W.; George William Locock, 2, St. James-square, Manchester.

Associates.—Henry Abrahams, Faraday House, Charing Cross-road; Edward Neville Bray, Manor House, Shere, Guildford; Alfred Collyer, McGill University, Montreal; Thomas W. Ellison, 82, Weinbergstrasse, Zürich, Switzerland; William Eversley Hardy, Park View, Alexander-road, Norwood; George William Hodder, St. Aubyn's, South Lowestoft; Chas. Henry Blackwood Longworth, McGill College, Montreal; Charles Picton Martin, 66, Victoria-street, Westminster, S.W.; John Willoughby Meares, Clive Hall, Shrewsbury; John William Morris, Wallace, N.S., Canada; John Walker Parr, "Wonham," Worsley-road, Hampstead; Evan Parry, 52, Glengarry-road, East Dulwich, S.E.; Gerard S. Peek, 11, Pavilion-square, Scarborough; Frank Henry Pitcher, 767, Wellington-street, Montreal; H. B. Price, The Arc Works, Chelmsford; Alexander Brodribb Randall, Archer's-road, Southampton; William Seymour, 94, Walton-street, Lennox-gardens, S.W.; Hilliard S. Stephens, 1, Wellington-chambers, Westminster, S.W.; James Roberts Sykes, jun., 15, Garville-avenue, Rathgar, Dublin; Lieut Oswald T. O. K. Webber, R.E.; Gilbert Winslow, B.A., "Crake Hall," Wimbledon Common, S.W.

Students.—Henry Chas. Ashton, 6, Ashmore-road, Harrow-road; Chas. Frederick Haswell Bayly, Moreton House, Kentish Town-road; Ernest E. Benham, 26, Church-gate, Loughborough; Leonard Harry Combe, Faraday House, Charing Cross-road, W.C.; Kenelm Edgcumbe, 33, Tedworth-square, Chelsea, S.W; Herbert Tyndale Haws, 29, Gladstone-road, Croydon; C. F. Hesketh, Penywern House, Earl's Court, S.W.; Leonard Johnstone, 3, Katharine-street, Croydon; Gustave Lemmens, High View, Anerley-road, Upper Norwood; G. P. Roy, the Royal Indian

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Engineering College, Cooper's Hill; Percy S. Sheardown, 107, Mildmay-road, N.; R. Valle, Penywern House, Earl's Court, S.W.; Harman Wigan, Cromwell House, East Sheen; J. G. Wilson, B.A., Penywern House, Earl's Court, S.W.; Thomas Parry-Osborne Yale, Faraday House, Charing Cross-road, W.C.

The following paper was then read:

ON METHODS OF TESTING THE MAGNETIC QUALITIES OF IRON.

BY GISBERT KAPP, MEMBER.

The industry generally comprised under the term "heavy electrical engineering" has of late years made such rapid progress that the question as to the kind of materials to be used has become of great importance. As regards the copper wire required in the construction of electrical machinery, certain standards regarding the size and conductivity have from the very first been adopted. The metal of commutator plates, size of wearing surface, type and number of brushes, dimensions of resistance coils, and other purely electrical parts of the machinery, have also, as a rule, been specified; but as regards the iron used no attempt was at first made to define it by specification. Makers of dynamos, for instance, broadly distinguished between cast-iron and wrought-iron field magnets, and got out their designs with reference to the magnetic properties each of these two kinds of iron was assumed to possess; but there was no certainty that the iron obtained did actually possess these properties. If the machines turned out according to design, well and good; if not, then the speed or excitation had to be altered so as to get the output right. This was the old and unscientific method of building electrical machinery. The modern method is very different, and far more certain. The manufacturer of a dynamo knows exactly what kind of iron he is using, and he is thus able to predetermine the performance of the machine with a degree of accuracy which formerly was impossible. This is especially of importance in large machines, as experimental runs to determine the characteristic at full load are not easily made, and are always expensive. In such cases it is preferable to cut a sample from the magnets, test it magnetically, and use the results of this test in designing the winding.

In some cases it is not even necessary to cut off samples and test them, as the manufacturers of forgings and castings for magnets offer now to supply these so as to conform to a certain magnetic standard, commonly defined by means of a curve in which the abscissæ represent magnetising force and the ordinates induction. Provided, then, the ironmaker supplies exactly the material which he has promised, the winding of the machine can be designed without any preliminary experimenting. Ironmakers are now keenly alive to the importance of this subject, and produce most excellent material. The testing of iron plates intended for use in alternators and transformers is another of those questions which had to be faced by manufacturers who wished to attain perfection in their work. As regards transformers, it will probably be admitted by all that the quality of the iron is the most important factor in the whole design. To make a good dynamo with inferior iron is still possible. We need only use enough of it, and spend enough money on the copper to make up for the deficiency in the iron. With transformers this cannot be done. If the iron is bad, no increase in its bulk, and no amount of money we may spend on copper, will enable us to turn out a good transformer. The important point with transformer plates is not the higher or lower permeability, but the waste of power by hysteresis and eddy currents; although to a certain extent the two go together, in the sense that a very soft iron having high permeability also has, as a rule, a small hysteresis loss. Plate-makers, recognising the importance of small hysteresis, now offer their material with a guarantee that the loss with a given induction and frequency shall not exceed a certain amount per pound.

Admitting, then, the necessity for magnetic tests of iron, the question as to method arises. There can be no doubt that the methods adopted by Dr. Hopkinson and Prof. Ewing in their classical researches give the most accurate results; but the very perfection of these methods forms a drawback to their adoption in engineering works where highly-trained experimenters cannot be found. I have therefore adopted other methods, which do not aim at absolute accuracy, but which can be used by any one of the staff generally found in the test-room of electrical engineering works. The apparatus required is on the table, and I venture to bring it before you because it has been in use for some years, and has given results which were always found sufficiently accurate for all practical purposes. It will be convenient to divide the subject into two parts—one dealing with the testing of magnet iron, and the other with the testing of transformer plates.

Testing-machine for Iron Bars.

This is shown twice full size in the wall diagram. For the principle on which it is based I am indebted to a little instrument devised some four years ago by Prof. Silvanus Thompson, and called by him a "permeameter." In it the induction through the sample bar is measured by the force required to pull the bar away from another piece of iron, and as the induction is proportional to the square root of this force, it is clear that any small error in the measurement of this force results in a still smaller error in the determination of the induction. Thus, if his spring balance were wrong by 2 per cent., the error in estimating the induction would only be 1 per cent. So far, then, as the determination of B was concerned, the permeameter appeared to be an exceedingly accurate instrument, but this alone is not sufficient. We must have the relation of B and H, and, as part of the total ampere-turns applied is required for the magnetic circuit outside of the sample, certain corrections must be applied in the determination of H. It was mainly with the object of making these corrections both small and definite that I altered the design of the Thompson permeameter and made it in the form shown on the diagram. The instrument consists of a heavy rectangular frame, made of the best Lowmoor iron, well annealed. Within the frame is fixed a solenoid with subdivided winding, so that a variable, but known, number of turns can be placed in circuit by using the various terminals provided on the instrument. The object of this arrangement is to keep the current within such limits as will ensure the greatest accuracy in its measurement, whilst the magnetising force is varied between very wide limits. A reversing switch is inserted to facilitate the investigation of the complete cycle.

The sample consists of a bar accurately turned and faced at the lower end. The bar is kept larger at the upper end, where it passes through a hole in the frame—a fairly tight fit—and it is centred near the lower end by a little gunmetal ferrule. Below the bar is a soft iron plunger, guided in a hole in the frame, and provided with an attachment for holding a scale-pan and weights. The plunger is made larger than the bar, and has a fine hole drilled through it to ensure good contact over the rest of the surface. The dimensions of the plunger and the hole in the frame being accurately measured, it is of course quite easy to determine by calculation how much of the ampere-turns provided is required to overcome the resistance of the annular air-space; and this is the only important correction required. The other corrections—such as the magnetic resistance of the frame, or that of the joint between the sample and the frame at the top—are quite trifling. Even the correction for the resistance of the air-space is only important for low inductions. For inductions above 10,000 it becomes relatively small, and above 15,000 quite negligible. The method of using the instrument is as follows: The sample, with its end carefully faced, is inserted from the top, and a small current sent through the solenoid, using the smallest number of turns. The plunger flies up against the sample and sticks there. The scale-pan is attached, and weighted until the plunger comes off. The exact point at which the weight overcomes the magnetic attraction is best determined by slightly varying the current by means of a rheostat; and I may mention that it is necessary to use a storage battery to provide the current. To work directly from a dynamo is impossible, as the slight variation in current produced by the irregularity in speed of the engine, or the flicking of a belt, is quite sufficient to make the tearing-off point uncertain. The current, number of turns in the solenoid, and the weight are now increased step by step, then decreased again to zero. The current is then reversed, and the operation repeated, so as to obtain the complete cycle. The values recorded are ampere-turns and tearing-off weight, in which is, of course, included the weight of the plunger and scale-pan. The greatest weight supported by a ¼in sample bar of good iron is about 45lb. I need not detain you by giving in detail the calculations for finding the relations between ampere-turns and H, or weight and B, nor the values of the corrections,* since these are purely elementary matters, and can be worked out for any testing-machine of this type if its dimensions are known. The time occupied in testing a sample through a complete cycle is about an hour; one man manipulating the weights, and the other the current. The latter also books the readings.

I have used the apparatus before you in testing large numbers of samples of cast iron, wrought iron, and mild steel submitted to me for investigation by different ironmakers, and some of the curves obtained are on the table. For obvious reasons I do not mention any particular maker of magnet steel; but I may say generally that the samples of steel submitted to me were very good, and in some cases better than wrought iron. The good qualities of mild steel as revealed by the testing machine were fully confirmed when the same material was used in dynamos, and thus tested on a large scale.

Testing-machine for Transformer Plates.

My first attempt to make such a machine was a failure, but as failures are sometimes as instructive as successes, I have placed the machine on the table for your inspection. In this machine I did not measure the power lost in the sample, but endeavoured to get an approximate means for comparing the permeability of different samples. An iron ribbon is coiled up to form a closed ring, and this is wound on opposite sides with coils so connected as to produce consequent poles over the two sides kept free from winding. The sample is made up of narrow strips into a flat bar, which is laid across the poles to form a magnetic bridge. The sample is surrounded by a pilot coil, and this is connected with an electrostatic voltmeter. If the same current is always sent through the main coils, and at the same frequency, then the volts produced by the pilot coil are supposed to give, roughly, an indication of the comparative value of the samples. The method

* In the instruments exhibited the corrections for top of sample, frame, piston, and air resistance collectively amount to $\frac{2{\cdot}37}{1{,}000}$ B ampere-turns, to be deducted from the total ampere-turns. Thus, for B = 12,000, which would be the lowest induction of practical importance, 28·5 ampere-turns would have to be deducted from a total of about 300; whilst for B = 15,000 the corrections would be 35·5 to be deducted from a total of about 1,500, and for higher inductions the correction becomes quite negligible. If P is the tearing-off weight in pounds, $B = 2{,}973\sqrt{P}$, and if X represents the corrected ampere-turns $H = \frac{X}{20{\cdot}2}$.

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was a failure, partly because permeability is not an absolutely reliable guide in estimating hysteresis loss, but chiefly because the uncertainty in estimating the magnetic resistance of the joints completely swamped any small differences that might have existed in the permeabilities of the samples. I therefore promptly abandoned this instrument, and set to work on another which would give directly that which we want to measure—namely, the losses at given inductions.

This instrument is shown on the table, and twice full size in the wall diagram. It consists essentially of a closed magnetic circuit of rectangular shape, the two longer limbs being enclosed in exciting coils. One long limb and the two uprights are composed of plates in one piece; the other long limb is formed by the sample plates, which are laid together so as to make up a certain weight, and are then bound together with tape and inserted through the top coil. The sample is fixed by wooden wedges. The coils are connected with a source of alternating E.M.F. through a wattmeter, and the instrument is thus ready for use without further preparation beyond making up a bundle of plates into a sample bar and inserting the latter. The instrument is calibrated once for all by making the sample and the fixed part, or yoke, of the magnetic circuit out of the same quality of plates, measuring the loss of power at different inductions, and apportioning the losses between the yoke and sample according to their weights. When testing other samples the total loss is measured by the wattmeter, and from this is deducted that portion of the loss which is occasioned by the iron which forms part of the instrument, the remainder being the loss in the sample. A correction must be made for the loss of power resulting from the ohmic resistance of the two coils, but this is exceedingly small. The induction is found from the E.M.F. applied to the coils and the frequency. In order to have a wide range of induction, and yet keep the measurements of current and E.M.F. within the limits most convenient for the instruments at hand, the coils are subdivided, and suitable terminals are provided. The resistance of the joints between the sample and the yoke is immaterial, as it influences only the current, but not the power.

The upper curve in the third diagram shows average results obtained in testing samples of plates furnished by several different suppliers of transformer iron. I say advisedly "suppliers," and not makers, because it sometimes happens that the same brand of iron, under different names, is supplied by different iron merchants. In fact, I have had a case in which two samples supplied by rival merchants gave precisely the same curve, and on making enquiries I found that the iron came indeed from the same maker, but was sold under different names. The lower curve shows the results obtained with the best sample I ever tested. As it is not my purpose, and as it would indeed be improper to advertise any particular maker in a paper of this kind, I trust you will not expect me to give his name. The curves are, for convenience in use, plotted under the supposition that the frequency is 100. The abscissæ give induction, and the ordinates loss of power in watts per pound of iron. The thickness of plates varied between 10 and 13 mils. Within these limits I believe that the thickness has only a very small influence on the loss—at any rate, I have not been able to detect any such influence; and this confirms an admirable investigation by Prof. Ewing, in which he showed, on theoretical grounds, that a reduction of thickness below about 13 mils is of no advantage. It is, of course, quite easy to test transformer plates by taking a known weight of stampings and making them up in a transformer with only one coil (preferably a low-pressure coil). If the same coil be always used for this purpose, the results will be perfectly reliable. The method is, however, tedious when a number of samples has to be tested, as time is wasted in building up and taking to pieces again the plates between each set of tests. With my testing-machine all the samples can be prepared beforehand and slipped in quickly one after another, so that the whole series of tests can be performed under the same conditions and by the same men. The facility with which samples can be changed is also of value if it should be necessary to verify any doubtful point in the curve obtained in a previous test.

There is another and very obvious method of testing transformer iron, and that consists in making up a complete transformer with the sample plates to be tested. Apart from the waste of labour entailed if the iron should turn out bad, this method is very uncertain. The reason for this uncertainty is that we test, not the iron alone, but the complete transformer, and we are thus left in doubt as to how much of the measured loss is really due to the iron. Theoretically, the whole loss is due to the iron, but in practice this is seldom the case. When testing a transformer immediately it is completed, and again after some weeks during which it has been regularly at work, you will find that its losses have become less. This I believe to be due to the coils having become thoroughly dry, and their insulation higher. A very small electrical leak in the high-pressure winding may easily lead to a waste of power, which, although small in itself, and not capable of doing any damage, is still appreciable when compared with the true iron loss. Take, for instance, a four-kilowatt transformer wound for 2,000 volts. Its iron loss would be about 2 per cent., or, say, 80 watts. Suppose, on testing this transformer, you find that the loss is not 80, but 100 watts. You might then conclude that the iron has 25 per cent. more loss than it ought to have, and you would condemn the sample. This might, however, be an unjust verdict. The extra 20 watts measured might very well be due to a general leakage of current across the turns of the coil. The leakage surface is large, and the pressure is large, so that the current density of the leak is very small, and no damage will be done. The leak vanishes as the transformer gets dry, and thus may be explained the curious fact that transformers get better after use. The moral of this is that to do justice to a transformer the final test should only be taken after it has been at work for some time.

In conclusion, I wish to express my thanks to Messrs. Johnson and Phillips for the loan of the testing-machines here exhibited.

TEST OF KAPP TRANSFORMERS: 100 FREQUENCY.

Size.	% Iron loss.	Full load efficiency.
3 k.w.	1·74	96·5
6 ,,	1·34	96·9
12 ,,	1·13	97·25
20 ,,	·95	97·4

DISCUSSION.

The discussion was opened by **Prof. D. E. Hughes**, who pleaded that he possessed no such great experience of testing the inductive qualities of iron as to qualify him to speak with authority. With the small instruments and appliances used in telegraph and similar work, he had found it most essential to secure great exactness in all the measurements. Of course, with the large powers involved in dynamo and transformer work such exactness was not so much required. Mr. Kapp's method seemed to him to have much to recommend it.

Prof. S. P. Thompson felt obliged to say that although Mr. Kapp had put his device in its first form to good practical use, yet he himself had also made considerable improvements in it, so much so indeed that its later form was to his mind even better than that employed by Mr. Kapp. The most recent type which he had used was constructed with a mass of iron surrounding the coil, having a cross-section not less than 200 times that of the test piece. The latter was the plunger itself, and was made much longer and thinner to eliminate sources of error due to magnetic reluctance. With regard to the transformer iron tests, he thought that the corrections which were necessary would vary considerably at different degrees of saturation. Prof. Thompson then went on to give the results of researches he had made upon the behaviour of large masses of iron serving—*e.g.*, as yokes in instruments or machines, and detailed some extremely interesting conclusions to which he had been led. For instance, in the case of a large sheet of good soft iron—large enough to be regarded practically of infinite area in comparison with the rest of the appliance—and not less than 10mm. thick, he had found it to act in all respects as a magnetic mirror. By placing a coil near such a plate he found that the latter acted as though it doubled the action of the coil, and by setting two such plates parallel with a coil between them, he obtained an effect similar to that given in optics by a like arrangement of glass mirrors—an endless coil in the one case, just as an endless image in the other. Prof. Thompson finally made a suggestion for measuring the inductive qualities of iron by means of an ebonite plate containing thin flat coils—entirely separated—placed between two blocks or masses of the metal to be tested.

Mr. Steele stated that a long series of tests had been made at Johnson and Phillips with strong steel and iron used in transformers and dynamos, and that the instrument devised by Mr. Kapp had yielded very accurate results. Two hours only were required in making and testing a sample.

Dr. Fleming observed that the paper was exceedingly important from the point of view of makers and of central-station people. Whilst the author's instrument might become extremely valuable, unless one had an opportunity of comparing the results of testing samples of iron with his instrument with those of the samples when made up in transformers, one would hesitate to accept them. Had Mr. Kapp tested them?

Mr. Sparks remarked that the results obtained with small samples cut from one sheet greatly varied, and marked differences were noticeable in one ton and in another ton of iron.

Prof. Perry informed Dr. Fleming that if he wanted pure iron, he should ask the cast-iron makers of Sheffield, who supplied real charcoal Swedish iron.

Mr. Mordey, who congratulated the author, said there was no more important question at the moment than that of getting good iron. The Brush Company had established a specification for the iron makers, and that answered well.

The **President** having made a few observations, the author replied to the discussion, and a vote of thanks to Mr. Kapp concluded the proceedings.

ELECTRIC SIGNALLING WITHOUT WIRES.*

BY W. H. PREECE, C.B., F.R.S.

What is electricity? Few venture to reply boldly to this question, first, because they do not know; secondly, because they do not agree with their neighbours, even if they think they know; thirdly, because their neighbours do not agree among themselves even as to what to apply the term. The physicist applies it to one thing, the engineer to another. The former regards his electricity as a form of ether, the latter as a form of energy. I cannot grasp the concept of the physicist, but electricity as a form of energy is to me a concrete fact. The electricity of the engineer is something that is generated and supplied, transformed and utilised, economised and wasted, meted out and paid for. It produces motion

* Abstract of paper read before the Society of Arts on Feb. 21.

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of matter, heat, light, chemical decomposition, and sound; while these effects are reversible, sound, chemical decomposition, light, heat, and motion reproduce those effects which are called electricity. Faraday's immortal researches, Clerk Maxwell's prophetic investigations, and Hertz's convincing experiments, have definitely and conclusively proved the existence of one medium throughout all space, called the ether, through which waves of energy, called radiations, are propagated with the same velocity, but in different forms and with different frequencies, although all of the same character. At one end of the scale we have actinic disturbances producing photographic impressions; at the other end of the scale electric waves producing elec tromagnetic disturbances, while the intermediate radiations give light and heat. Actinic waves are extremely minute, and number many millions per second, electric waves are very long and may number only hundreds per second. Like light waves, they are propagated in straight lines, they obey the laws of reflection, they are refracted, they are subject to interference, and they may be even polarised.

We have to consider electric waves to-night, and I want to show you how we are gradually, by patient plodding, creeping along towards the period when I hope we shall be able to make real practical use of such electromagnetic disturbances. If we take a conductor through which a rapidly alternating current is being supported by any means, it throws the ether which surrounds it into oscillations. Energy is thus radiated away in electric waves. These electric waves spread out in all directions, as do waves of light, and if they fall on similar conductors properly placed and sympathetically prepared, these waves of energy are transformed back again into alternating currents which give evidence of their presence. Their presence is indicated by a telephone if the frequency of the alternating currents is brought within the range of the ear. Hertz and his followers experimented with waves of much shorter length, and with sparks in air, but all my experiments have been made with telephones and with waves comparable in frequency with those of sound. The prime source of energy has been either a steam-engine or a galvanic battery. This has produced, by suitable machinery, rapidly intermittent or alternating currents, which have been transmitted through a primary circuit. At some distance away from this circuit there has been a secondary telephone circuit, and between these two circuits the only connecting medium has been the ether, which has been thrown into electric oscillation, and it has been across this space that I have been signalling without wires. In all cases, the primary currents were of such a frequency as to produce a musical note in the telephones fixed in the secondary circuit, which could easily be read, if sent in the dots and dashes of the Morse code. Signalling through space is very fascinating. I have now for 10 years been steadily investigating the subject.

[The author then referred to experiments made in this direction by himself and by others on his behalf. The results of these experiments were given in a paper read by Mr. Preece "On the Transmission of Electric Signals through Space," before the Electrical Congress at Chicago on August 23, 1893. This paper, together with illustrations, was reproduced in the *Electrical Engineer* of August 25 and September 1, 1893, and to which we refer our readers.]

As the laws governing these effects [those observed in the case of the experiments referred to] were by no means so clear and conclusive as such probing and enquiring deserved, Mr. Gavey and Mr. Kempe conducted for me a very careful series of experiments near Frodsham, on the estuary of the Dee, which was found to be a more convenient locality than Conway, and the very satisfactory results obtained will shortly be published. The conditions are now so clear that, given the localities between which it is desired to communicate, it is a mere matter of calculation to show what has to be done. It would be quite easy to speak between France and England across the Straits of Dover. There happens to be a convenient and accessible loch in the Highlands — Loch Ness — forming part of the route of the Caledonian Canal between Inverness and Bannavie, having a line of telegraph on each side of it. Five miles on each side of this loch were taken and so arranged that any fractional length of telegraph wire on either side could be taken for trial. Ordinary and not special apparatus was employed, sending messages, as before, by Morse signals, and speaking by telephone across a space of one and a quarter miles was found practical, and, in fact, easy; indeed, the sounds were so loud that they were found sufficient to form a call-for attention. The following apparatus was in use on each side of the loch for the transmission of Morse signals: A set of batteries, consisting of 100 dry cells, giving a maximum voltage of 140; a rapidly-revolving rheotome, which broke up the current into a musical note; a Morse key, by which these musical notes could be transformed into Morse signals; resistance coil and ampere-meters to vary the primary current; two Bell telephones joined in multiple arc to act as receivers. For the transmission of actual speech simple granular carbon microphones, known as the Deckert's, were used as transmitters, and a current of two amperes was maintained through these and two Bell telephones in circuit with the line wire. Any lingering fear that earth conduction had principally to do with these results was removed by making the earth's terminals on the primary circuit at one end at Inverness nine miles away, and at the other end in two directions in a parallel glen about six miles away. The early experiments of 1886, in the valley of the Severn, had placed this question of earth interference beyond the region of doubt, but earth conduction, as a main factor in the results, is still believed in by critics. The function performed by the earth has been thoroughly developed in the Frodsham experiments, and will be discussed subsequently.

One very interesting fact observed at Loch Ness was that there was one particular frequency in the primary circuit that gave a decided maximum effect upon the telephones in the secondary circuit. This proves the presence of resonance, and is, of itself, a fact sufficient alone to prove the effects as being due to the transformation of electric waves into electric currents. It is well known that every telephone has one particular note—the natural note of the disc—to which it responds better than to any other, but this resonant effect far exceeded in magnitude any difference due to the natural pitch of the disc. It was not the natural note. Conversation by telephone, though possible, was not, however, practical. Still, it is something to have transmitted speech by electricity across an air-space of 1¼ miles. We had this curious condition, that at some intermediate point the energy of the human voice was found side by side in two different forms—sonorous vibrations in the air, and electric waves in the ether. There is now no difficulty in communicating with outlying islands if the conditions are favourable. The Northern Commissioners of Lights are anxious to establish electrical communication with the Muckle Flugga lighthouse, at the extreme north of the Shetland Islands, but the place is so inaccessible that, though the conditions are favourable and signalling without wires is possible and simple, it would be more prudent to adopt the more expensive plan of a submerged cable. I would rather inaugurate the system nearer home, where it could be watched, nursed, and improved. Anyhow, it is something to be able to report that we have now acquired a practical system of signalling across space without the necessity of using wires.

Although this short paper is confined to a description of a simple practical system of communicating across terrestrial space, one cannot help speculating as to what may occur through planetary space. Strange, mysterious sounds are heard on all long telephone lines when the earth is used as a return, especially in the calm stillness of night. Earth currents are found in telegraph circuits, and auroræ borealis light up our northern sky when the sun's photosphere is disturbed by spots. The sun's surface must at such times be violently disturbed by electrical storms, and if oscillations are set up and radiated through space, in sympathy with those required to affect telephones, it is not a wild dream to say that we may hear on this earth a thunderstorm in the sun.

SOME NOTES ON THE ELECTRIC LIGHTING OF THE CITY OF LONDON.*

BY MAJOR-GENERAL WEBBER, R.E., C.B.

(Continued from page 204.)

Distribution.

Outside the postal telegraph and the city engineer's offices there was no one who could form any accurate idea of the condition of things below the surface of the City streets. The subways in Victoria-street, in Arthur-street, and in the Holborn-viaduct, although suitable for through mains of supply of any kind, were eminently not so for electric distribution conductors, which have to be tapped at frequent intervals for the supply of current for public and private lighting. Although forced to use them, the cost of such mains and services to a supply company is higher than if the lines were laid under the footway on either side.

In March, 1890, the London County Council, with the approval of the Board of Trade, and the confirmation of the Home Secretary, under the terms of the Metropolitan Subways and Government Acts of 1868 and 1888, had published by-laws for regulating the use of subways. These, while in force in the Queen Victoria-street subway, are not so in those under the Holborn-viaduct and Arthur-street. Anyone who has used street subways for electrical conductors in common with gas, water, and other companies, will understand that, except for primaries, the electrical engineer would much rather remain outside. The by-laws are excellent for the regulation of this user, but the panacea, which excellently-intentioned persons believe exists in street subways falls short of theirs and the public's expectations. The law allows the local authority to oblige us to use them where they exist, and to charge us a rental for that use; but as the word "pipe" in the Act includes a "tube for wires," and as the rental, irrespective of the number of wires, is £16 per annum for a 3in. pipe for the 1,200 yards of the Queen Victoria-street subway, and £49 per annum for one under 18in. diameter for the same length, the way-leave is not very costly, but the cost of using it is extremely so. Sections of some of the subways, with the conduits placed in each for electric light conductors, are shown. In each case, the obligation to use the subway instead of the ground under the footways entailed one excessive expenditure common to both—namely, the works in breaking through the massive arches and deep cuttings in the roadways to get at the street lamps, and, in many places, to obtain access to the houses, in some places 30ft. away. In the Arthur-street and Holborn-viaduct subways a large number of "ways" in Callender-Webber casing have been secured at a very little cost. In the Queen Victoria-street subway, cast-iron troughing on wall brackets, as first designed, proved an awkward and costly arrangement in many ways; the weight of the structure was nearly 3cwt. per yard. Lighter troughing designed by me was adopted, of which follow sections. The trough contains cables—six of 1·9in. external diameter, three of 1·5in. external diameter, and four of 0·7in. external diameter;

* Paper read before the Institution of Electrical Engineers.

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with a carrying capacity in section of copper available at 2,000 volts = 0·09in., at 200 volts = 2·1in. Weight of trough per yard = 90lb.; cost of trough, fixed, 16s. per yard—with conductors, high-insulation bitumen, £4. 2s. per yard run. The essential

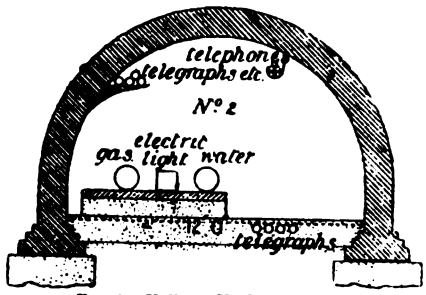

FIG. 2.—Holborn Viaduct Subway.

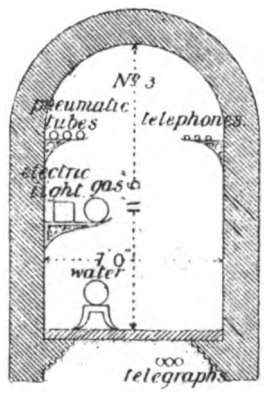

FIG. 3.—Holborn Viaduct Narrow Subway.

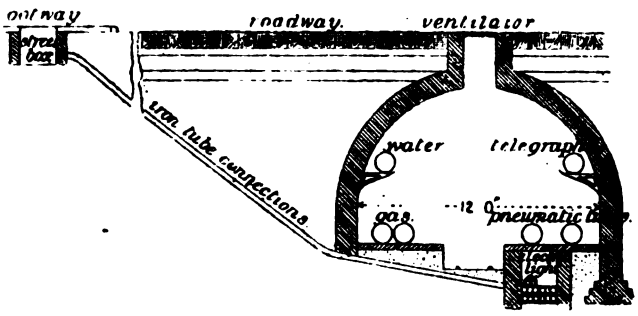

FIG. 4.—Subway, Charterhouse-square, with Street Box.

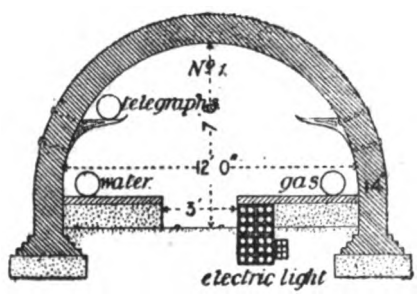

FIG. 5.—Subway, Arthur-street.

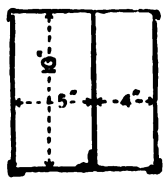

FIG. 6.—Section, Square Trough.

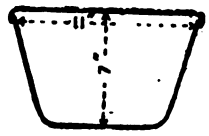

FIG. 7.—Section, Rolled-Iron Trough.

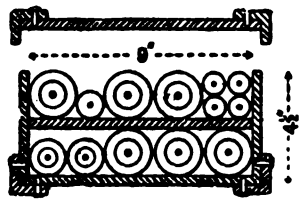

FIG. 8.—Section, Trough with Cables in it.

objections to working in such subways (apart from maintenance) are (1) the difficulties, physical and otherwise, of access to them, both for *personnel*, material, and plant; (2) the delays to work, due (*a*) to defective lighting, (*b*) time required to communicate with the authority and other occupiers, (*c*) to foul atmosphere; (3) the engineering obstacle due to the works of previous occupiers, and to the cutting in and out where necessary to reach side streets.

My own postal telegraph experience in 1871 and 1872 had been in the difficult ground in thoroughfares like Cornhill; and although in 1891 and 1892 places were come upon where hardly a single conduit could be laid, the task, owing to the system adopted, proved, on the whole, less difficult than was anticipated; and, as was expected generally, the thoroughfares running north and south were easier than those east and west, for the reason that most water, gas, and telegraph mains tend from the City towards outside centres in those directions. The pioneer work included the opening of certain main thoroughfares, so that the arc lighting might be got forward. In these, the most thronged streets of the City, it was essential not to have to repeat the inconvenience of opening the ground. Whatever was laid down at the first operation had to form a portion of, and suffice for, the completed scheme. In a matter so long under my own consideration I had no hesitation in recommending that sufficient conduit accommodation should be provided, and that it should take the following form—viz.:* (*a*) iron pipes for concentric high-tension mains from the generating to the transforming stations; (*b*) iron pipes for continuous-current high-tension mains for the public arc lighting; (*c*) bitumen concrete casing for three ways, to accommodate the conductors of a low-tension distributing system, both feeders and distributors.

The future needs of the great whole had, as I shall describe further on, to be thought out before March of 1891, so that each part of the work, however preliminary, should eventually fit in to the permanent system. The future need for spare conduits, possibly for telephones, had also to be thought of, and it was provided for as far as the very limited space under the footways of those thoroughfares which were first treated would permit. The question of interference, through the neighbourhood of alternating-current working, with telegraph and telephone circuits was at that time under public discussion. I had very little time, and had to be satisfied with one experiment having the object of observing the screening effect which was anticipated would exist through the interposition of what might be called "faggots" of iron pipes, lying in the same trench as the non-conducting conduits, into which the low-tension distributing mains were to be drawn. For the experiment, conduits and pipes were laid on trestles under nearly the same conditions as in the trench, and a 200-volt current with 100 frequency (obtained by transformation) and 100 amperes was passed through two of the three ways of a bitumen

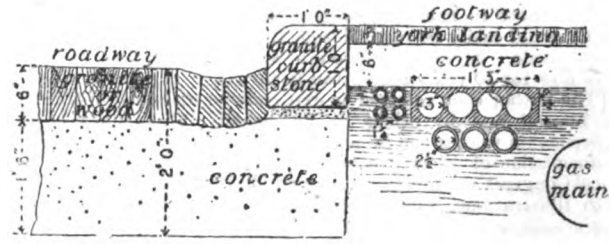

FIG. 9.—Sections of Road.

concrete conduit in conductors having a sectional area of copper of about one-tenth of an inch. Telephone circuits with metallic† returns laid parallel were tried. The iron tubes were placed at various distances and in various numbers. Imperfect as the trial was, it gave us security that at a distance of 12in. from the Callender-Webber casing, twin telephone circuits in iron pipes would be fairly secure from trouble. But, as an additional precaution, it was decided to sheath the casing with iron. Within a distance of about 6in. a very slight disturbance could be still heard. A sample of casing thus treated is on the table amongst the other samples illustrated.

The choice was further justified, because the Duke of Marlborough, with his usual foresight, asked several practical engineers to meet him in a friendly way soon after this advice had been given and adopted, in order to discuss the whole question. From my notes of that meeting, held on March 23 and 24, 1891, I find the conclusions then come to coincided with the system above referred to, which was already in course of execution. Those present at this meeting were the Duke of Marlborough; Messrs. T. Callender, Gordon, Gray, Heaviside, Mavor, Raworth, A. Siemens, Wharton, and Major-General Webber. It is not to be assumed that unanimity on matters of detail was expected or arrived at. As regards anticipated electrical troubles, the avoidance of interruption of telegraph and telephone circuits was the only thing dealt with at those consultations. Those present had till then had, I must presume, no practical experience of the

* The entire responsibility of thus advising the pioneer company rests with me. As the pioneer contracts (with the making of which I had nothing to do) had only provided conduits sufficient for the cables from the pioneer generating stations, and had specified nothing as regards the underground conditions, it was necessary, in order to prevent the consequent waste of having to excavate the same ground twice, to make additional provision. And as the isolated areas treated by these pioneer contracts had to be considered as forming a part of the great whole, the whole of the details of the completed work had to be gone into.

† Experiments made in 1880 with telephone circuits with and without earth returns, between Paddington and Westbourne Stations, laid in the same wooden troughs as 40 or 50 working single and double current telegraph circuits, saved me from having to make any trial with earth return for the telephones.

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resistance due to skin effect, or self-induction, in the case of single conductors of over one-third of an inch section of copper used to convey alternating currents at low pressure. The use of concentric lead-covered cables laid in the earth, with iron split-tube protection where joints have to be made, was discussed with the advocates of that system as used in Germany, and its advantages, both as to reliability, manageability, and first cost, in comparison with two or more highly-insulated conductors in one iron pipe, were weighed, especially in view of the claim that, wherever laid, it is everlasting. The question of influence on telegraphs and telephone, and the means of screening or damping down the magnetic field, was discussed, and various experiences at Bath, Newcastle, and in London were quoted.

The following recommendations were formulated, with general concurrence: (1) that a separate way should be provided for each separate conductor, for the purpose of drawing in and out between flush boxes; (2) that the high-tension primary alternating currents should have concentric conductors with vulcanised rubber dielectric, and be drawn into iron ways; (3) that the arc lighting continuous current conductors should be concentric, and drawn into an iron way, except in the lengths where the circuit is connected with lamps, when the 7/16 conductors should be separate, so as to avoid joints.

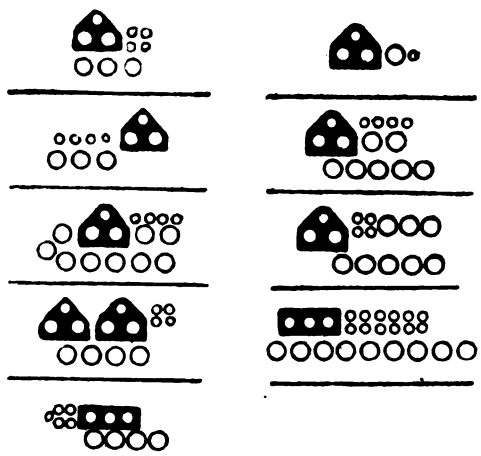

FIG. 10.—Various Typical Examples of Sections of Conduits.

In connection with the secondary distributing conductors, the use of the three-wire system having been admitted, various means of laying were examined—such as large iron pipes, with and without interior separate ways for the cable; the use of paper tubes in iron cases; iron tubes lined with bitumen: and earthenware cases, with ways similar to the Callender-Webber bitumen concrete cases. After carefully considering the conditions of the City streets, and all the circumstances of difficulty that were being met with and known to exist, the use of bitumen concrete cases with separate ways; and, in view of the experience and evidence of its efficiency, the use of Callender's bitumen insulation for the secondary distributors, met with approval. After hearing all that was to be said as to the conditions for providing drawing-in and joint boxes in the City streets, no doubt remained as to the necessity for using a common box in most situations for all main circuits and their joints, and of making them as large as the space below the surface would permit.

The justification of the adoption of these resolutions was, both from the engineering and financial point of view, as follows: The use of footways wherever possible had been prescribed by the Commissioners. In spite of having to keep 6in. under the lower side of the paving-stones, it entailed less labour in excavating. In the lines where they had to be carried under roadways, the conduits had to be below paving and concrete, sometimes 2ft. in thickness; with a surface subject to such traffic the numerous draw, service, and other flush boxes would have been impossible.

The following figures give an idea of the traffic in the City—by bridges, streets, railway stations, landing piers, and subways there are 81 means of public access. By these the daily traffic was:

	1881.		1891.
Vehicular—During 16 hours ...	66,909	.....	85,286
During 8 hours.....	4,984	.....	6,546
Pedestrian—During 16 hours...	739,640	.....	1,100,636
During 8 hours.....	57,923	.....	85,458

The space available below the surface was occasionally entirely occupied by cellars, areas, and other pipes, and the work had to be carried out in the presence of officials representing (1) the Commissioners of Sewers, (2) the Postmaster-General, (3) the gas-light company, (4) the water company, (5) the hydraulic main company, (6) the district surveyor. The condition, exacted rigorously—namely, that no pipe or conduit should be placed vertically over, or within 6in. horizontally of, an existing pipe—was a most arduous one to fulfil.

My procedure in the most difficult streets was as follows: Having decided on the maximum number of "ways" that should, and if possible be, laid under the footway, I began by examining it personally, having first obtained from the authorities I have named all possible information as to their pipes—information that was sometimes very imperfect. I then measured carefully all cellars, arches, and areas, and had trial holes opened wherever exceptional difficulty was anticipated. In many cases, such as in King William-street, so contracted was the space that several ways which were actually necessary had to be omitted and taken another way, and occasionally a deviation under the roadway was obligatory. The intricacies of the trench opened under such conditions could not, I believe, have been followed with any other system of ways—namely, the combination of Callender-Webber casing and wrought-iron tubes. Both these are capable of being bent on the ground to any reasonable curve—in the case of the iron pipes by the ordinary means, and in the case of the bitumen-concrete cases either by warming the case and bending it when soft, or by laying short lengths and setting them at an angle to one another with mitred ends; the length of the short pieces and the angle of the mitres being, of course, dependent on the radius of the segment of the curve that has to be followed.

The difficult problem that faced the company in August, 1891, was the obligation to lay down their mains and complete the public lighting in all parts of 53 streets by February, 1892, requiring approximately 17 miles of trench; and that the Commissioners were likely to be very stiff as to punctuality. A careful consideration of the case in its various aspects had led me, when acting (up to and before 1890) as technical adviser to the Brush Company, to regard the adoption of alternating currents, delivered at high pressure and distributed at low pressure, as the service most suitable for private lighting in the City. There was no hesitation on the part of all concerned to adopt it, particularly as in the case of the contractors the Mordey and Thomson-Houston systems had in in 1890 reached considerable perfection. The conditions which emphasised this view in my mind were geographical and local as regards the City. Whatever may have been the ultimate practice they were paramount during the preliminary stage. They were, first, on account of cost of ground, that the generating stations should be at a distance; second, on account of the exceptional difficulties in the streets for laying mains, the desirable frequency of converting stations might be impossible to achieve. When the *concessionaires—i.e.*, the contractors—had the matter in their own hands, the sites already named for the generating stations were secured in, or in close proximity to, the City. Although this was a reversal of conditions, the selections were probably wisely influenced by question of facilities for sea-borne coal and condensing water, and largely controlled by the difficulty created by the Electric Light Acts in getting way-leaves through the areas of neighbouring local authorities. For instance, negotiations extending over three years, with that object only, that I had conducted for the Brush Company with some local authorities on the Surrey side, ended only in obliging the company to seek and obtain a provisional order for the St. Saviour's district.

(To be continued.)

COMPANIES' MEETINGS.

CITY OF LONDON ELECTRIC LIGHTING COMPANY, LIMITED.

The ordinary general meeting of the above Company was held at Winchester House, Old Broad-street, yesterday (Thursday) afternoon, to receive the directors' report and accounts, which were given in our last issue. Sir David L. Salomons, Bart. (chairman of the Company), presided.

The **Chairman**, in moving the adoption of the report, stated that impartial people would agree that it gave a fair and impartial view of what had taken place. They did not regret the absence of fog during the winter, for it had enabled them to get their machinery erected. It was the pioneer station which had brought in the revenue, and they had increased from having 20,241 8-c.p. lamps on their system at the beginning of the past year, with a capacity of 34,000, to 65,341 8-c.p. lamps at the end of the year, with a capacity of 64,000. At the present time 76,000 lamps were connected, and the machinery had a capacity of 100,000. In addition, 25,000 lamps had been applied for, but they were not yet connected; they would be when the transformer stations were equipped. All the sub-stations should be ready by April, but allowing for delays they would in any case be completed by the end of the year. Taken on the basis of the present nine areas supplied, the other 13 areas should bring up the number of lamps to 180,000. The directors had started, apart from the ordinary reserve, a fund for the mains which was invested in consols. The total extinctions during two years' working only amounted to one hour. In order that the streets should not be placed in darkness by any accident, the arc lamps on different sides of the streets were fed from separate circuits. The City authorities had now ordered the gas-lamps to be removed from the thoroughfares lighted by the Company, and that showed that they had confidence in them. There would now be 23 miles of streets in the City lighted by electricity alone. They had received an order to light Smithfield Market, and hoped to receive one to light the lesser streets. The proposed issue of £100,000 in debenture stock at 5 per cent. would be revenue-earning. The directors were thinking of publishing quarterly returns like the railway companies. There were now 1,700 shareholders in the Company. Sir David Salomons, in conclusion, acknowledged the merits of the whole technical staff, who had worked most excellently.

Mr. Joseph B. Braithwaite, jun., seconded the adoption of the report, and pointed out that the cost of production of electricity had decreased by 32 per cent. as compared with the

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preceding year. With regard to the issue of debenture stock, this had not taken them by surprise, for it had been anticipated in the original prospectus. The directors had pursued a steady and fixed policy from the beginning. The debentures would not only earn their own interest, but probably 15 to 20 cent. in addition.

The motion was then put to the meeting and carried.

The **Chairman**, in reply to Mr. W. Cooper, who drew attention to the returns of the Westminster Company with almost the same output and the same revenue, but which had a far smaller capital, pointed out that the Westminster Company was at its zenith, while they were engaged in initial work. In reply to other questions, he stated that the debentures would be issued in a few days at the price of £115, redeemable at £125 after the year 1911.

Sir David Salomons moved, and **Mr. Edward Lucas** seconded, the payment of a dividend at the rate of 6 per cent. on the preference shares, which was agreed to.

Mr. J. W. Reynolds moved, and **Colonel H. B. Martindale** seconded, the re-election of Sir David Salomons as chairman. This motion was adopted. Messrs. W. H. Pannell and Co. were re-appointed auditors, at a fee of 100 guineas, this terminating the proceedings.

WESTMINSTER ELECTRIC SUPPLY CORPORATION.

The ordinary general meeting was held at Eccleston-place, Westminster, on Wednesday, Lord Suffield in the chair.

The **Chairman**, in moving the adoption of the report, which was published in our last issue, congratulated the shareholders on the steady increase that had been going on in the business of the Corporation, and also in its income and dividends. He was glad to say that their revenue had largely increased, notwithstanding the adverse circumstances which had had to be encountered, and which included, first, the strong competition to which the Corporation had been exposed; in the second place, the fact that the charge per unit had been reduced by 1d. for nine months of the year; and thirdly, the abnormal amount of light that had prevailed during the winter to the almost entire absence of fogs. The aim of the Board had been to pay dividends out of actual profits, and to put the business of the Corporation on a sound basis rather than pay large dividends at the commencement. They were, however, highly pleased to be able to declare an increased dividend over the corresponding period of the previous year, after having written off several liberal amounts for preliminary expenses and patents, and making provision for depreciation, sinking fund, working expenses, and bad debts—the last-named item being small in amount. During the past year, in conjunction with other low-tension companies in London, the Board had come to terms with the Westinghouse Electric Company for the use of the Hopkinson patents for the three-wire system of distribution, and had obtained a license for the remaining term of the patents and any extension thereof. The cost of the license had been £3,878, and as the issue of the patents had saved a much larger expenditure in copper for the mains, the amount had been charged to capital. There was no likelihood of their having to incur any further outlay for patents of any kind. No item chargeable to revenue had been carried to the capital account, the plant, machinery, etc., being fully maintained out of the revenue of the year. The Corporation had been but little affected by the coal strike, as they had provided a large supply beforehand, which had carried them over the bad period. The installation of current to the mains for the supply of the Foreign Office had been satisfactorily accomplished. The Government authorities had decided on doing away with the plant previously supplied for lighting the Houses of Parliament, and would now take the whole supply for those buildings from the Corporation mains. It was hoped before long other large Government departments would be added.

Mr. J. H. Powell seconded the motion for the adoption of the report, which was agreed to unanimously.

On the motion of the **Chairman**, seconded by **Mr. Martin**, a dividend at the rate of 5 per cent. per annum was declared for the past half-year, and the chairman and Mr. Hayes Fisher, the retiring directors, having been re-elected, and the auditors, Messrs. Cooper Bros. and Co., having been reappointed, a vote of thanks to the chairman closed the proceedings.

ORIENTAL TELEPHONE AND ELECTRIC COMPANY.

An extraordinary general meeting of the Oriental Telephone and Electric Company, Limited, was held on Wednesday at the Cannon-street Hotel.

Mr. W. Addison, who presided, said that since the present Board had been directing the affairs of the Company, they had from time to time endeavoured to arrive at an understanding by which the two classes of shares into which the share capital was divided should be assimilated, thus abolishing the liability on the partly paid-up shares, and bringing in the vendors' shares for immediate dividend for reduced capital. A provisional agreement had now been arrived at, and though it was true that the ordinary shareholders would have to submit to a reduction of 1s. per share, it must be borne in mind that the vendors also reduced their 20s. shares by 4s. 6d. each. The paid-up capital would thus be reduced from £199,746 to £171,497. The ordinary shareholders would be relieved from all liability as to calls, and the holders of vendors' shares would come in for immediate dividend.

The **Solicitor** (Mr. J. Addison) having explained the proposal, resolutions were passed, after some discussion, providing for the voluntary winding-up and reconstruction of the Company for the purpose of carrying the scheme into effect.

CHELSEA ELECTRICITY SUPPLY COMPANY, LIMITED.

Directors: J. Irving Courtenay, Esq., chairman; Major-General Webber, C.B. (retired, R.E.) deputy-chairman; Nugent Daniell, Esq., Emile Garcke, Esq., Sir George Prescott, Bart. Managing engineer, Frank King, Esq. Secretary, S. J. Cluer.

Directors' Report.

The directors have pleasure in submitting to the shareholders the report and statement of accounts for the year ended December 31, 1893. The net profits of the year on the ordinary business of the Company, after payment of interest on debentures, amount to £4,004. 4s. 6d. This sum, together with the balance from the sale of the South Kensington district, gives a net balance of £6,605. 2s. 7d. To meet the wishes of the Board of Trade, the sum of £4,674. 3s. has been deducted from the item of "preliminary expenses" in capital account, and transferred to a suspense account, which account it has been decided to reduce by writing off £2,500. A further sum of £1,000 has been placed to renewals and depreciation fund account, leaving a balance of £3,105. 2s. 7d. available for distribution. The directors recommend the payment of a dividend on the ordinary shares of 5 per cent. for the year, and that the balance of £619. 4s. 3d. be carried forward to next account. In May last, the purchase of the works, machinery, and mains of the Cadogan Electric Light Company was concluded. The generating station, situated in Manor-street, Cheyne-walk, is of sufficient dimensions to contain plant to meet a large increase in the demand. Extensive improvements and additions are in progress at this station. During the year about 20,000 yards of new conductors have been laid. The increase in the number of lamps connected to the service during the year is 10,665; and, deducting the number of lamps transferred with the South Kensington district, the total number on the Company's mains on December 31, 1893, was 40,665. The transfer of the South Kensington district, authorised at the extraordinary general meetings held last year, was completed in June. The satisfactory reduction made in the last few years in the working cost is shown in the following statement of the cost per Board of Trade unit sold:

Year.	Coal.	Stores and water.	Wages.	Maintenance.	Rent, rates, and taxes.	Management.	Renewals and depreciation fund.	Total.	Capital expenditure.	Board of Trade units sold.
	d.	d.	d.	d.	d.	d.	d.	d.	£	
1891	2·22	·74	1·11	·93	·21	1·56	—	6·67	74,721	290,458
1892	1·63	·59	·95	·71	·21	1·26	·67	6·02	81,364	357,162
1893	1·11	·35	·80	·53	·48	1·17	·59	5·03	99,483	402,848

The retiring directors are Mr. J. Irving Courtenay and Mr. Nugent Daniell, who, being eligible, offer themselves for re-election. The auditors, Messrs. Cooper Bros. and Co., also offer themselves for re-election.

Revenue Account, Year ending Dec. 31, 1893.

Dr.		£ s. d.
A.—To Generation of Electricity.		
Coal or other fuel, including expenses on the same	£1,863 14 6	
Oil, water, cotton waste, and engine-room stores	504 19 3	
Wages of men	1,000 14 8	
Repairs, maintenance, and renewals: buildings, £61. 3s. 11d.; engines and boilers, £323. 11s. 4d.; dynamos, £11. 2s. 10d.; instruments, tools, and sundries, £82. 11s. 5d.	478 9 6	
		3,847 17 11
B.—To Distribution of Electricity.		
Wages at out-stations, meter winding and reading, etc.	340 17 1	
Stores used at out-stations, etc.	28 16 6	
Sundry costs not included in above	61 18 6	
Repairs, maintenance, and renewals: mains, £20. 10s. 7d; accumulators and apparatus at distributing station, and motor transformers, £358. 16s. 1d.; meters on consumers' premises, £31. 12s. 8d.	410 19 4	
		842 11 5
C.—To Rent, Rates, and Taxes.		
Rents payable	480 0 10	
Rates and taxes	325 0 5	
		805 1 3
D.—Management Expenses.		
Directors' remuneration	600 0 0	
Salaries of staff	747 3 2	
Salary or commission of collector	91 7 5	
Stationery and printing	61 14 4	
General establishment charges	202 12 2	
Auditors of Company	25 0 0	
Auditors appointed by the Board of Trade	28 14 2	
		1,756 11 3

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E.—To Law and Parliamentary Expenses.

Law expenses		126	7	8		
					126	7	8

F.—To Special Charges.

Insurance		79	17	4		
Way-leaves		5	0	0		
					84	17	4
Balance, being gross profit					6,268	13	2
					£13,732	0	0

Cr.	£	s.	d.
Sale by current (less allowance made)	13,078	8	6
Rental of meters	447	19	8
Transfer fees	1	12	6
Rents receivable and sundry small accounts	203	19	4
	£13,732	0	0

Dr. Net Revenue Account.	£	s.	d.
Interest on debentures paid and accrued to date	2,143	10	10
Fees to trustees for debenture-holders	100	0	0
Interest on mortgage of freehold (purchased subject to mortgage) and on loans	105	17	2
Renewals and depreciation fund account	1,000	0	0
Amount written off suspense account	2,500	0	0
Bad debts written off	91	10	9
Balance available for dividend on the ordinary shares	3,105	2	7
	£9,046	1	4

Cr.	£	s.	d.
Balance from last account	1,336	2	7
Less dividend of 2½ per cent. paid on the ordinary shares	1,159	12	6
	176	10	1
Balance from revenue account (being gross profit on working)	6,268	13	2
Balance on sale of South Kensington district	2,600	18	1
	£9,046	1	4

Dr. General Balance-sheet, Dec. 31, 1893.				£	s.	d.
Capital account—amount received				88,785	0	0
Bills payable				6,803	4	11
Sundry creditors				4,852	12	4
Advance from bank (secured by deposit of £7,500 second debentures)				4,000	0	0
Net revenue account—balance at credit thereof				3,105	2	7
				£107,545	19	10
Cr.	£	s.	d.	£	s.	d.
Capital account—Amount expended	99,482	16	0			
Less renewals and depreciation fund account	1,000	0	0	98,482	16	0
Stores on hand—Coal	48	0	0			
General stores, including work in progress	786	10	7	834	10	7
Preliminary expenses in suspense	4,674	3	0			
Less amount written off	2,500	0	0	2,174	3	0
Sundry debtors for current supplied, etc., less bad debts deducted				5,438	15	5
Cash at bankers	594	2	3			
Cash in hand	21	12	7	615	14	10
				£107,545	19	10

The annual ordinary general meeting of this Company was held on Tuesday at the central station, Draycott-place, Chelsea, Mr. J. Irving Courtenay, the chairman, presiding.

In moving the adoption of the report, the **Chairman** stated that the progress made during the past year had been so satisfactory that there was a considerable increase in the profits, the dividend of 5 per cent. recommended on the ordinary shares being double that paid last year on a paid-up capital over 10 per cent. larger than that of 1892. The dividend came out of the ordinary business of supplying current, and was independent of the exceptional item of £2,600, the balance from the sale of the rights of the South Kensington district. Considerable expenditure had been due to an extension in the mains, and a large area had been covered extending from the Chelsea-embankment on the south to the Fulham-road on the north. This area, it was expected, would develop in the future in the same way as the area previously occupied by the Company's mains. They had been fortunate in purchasing the works of the Cadogan Company at a time when an increase in their generating power was necessary. They were being arranged for 1,000 effective horse-power, which could supply power for 75,000 lamps of 8 c.p. fixed, or, say, 30,000 lamps in use at one time. The total number of lamps on the Company's mains at the end of the year was 40,665. The number of customers in the new area in which the mains had been laid was rapidly increasing, and there was also a large increase in the area previous supplied, and the Cheyne-walk station was about to be used to assist the Draycott-place station as well as to supply the new area. The condition of the plant was excellent, and its efficiency well maintained. The report showed that the cost of production had been reduced within the last three years by the amount of 1¾d. per Board of Trade unit sold, and there was last year a sale of 402,848 units. The number of units sold would have been larger still had it not been for the unusual absence of fog. The increase in capital expenditure had resulted in a much larger proportion of profits, as there were certain fixed charges which barely increased at all while the revenue increased, and adequate capital enabled the Company to provide and arrange their plant so as to give the best results. Fresh capital would have to be raised for the additional machinery and plant necessary to meet the growth of the Company's business. The directors consequently intended to exercise the powers already given them by the shareholders, and would at an early date make an issue of preference capital.

Major-General Webber, in seconding the adoption of the report, said that had there been seven more foggy days, with a consumption of six hours by three fourths of their lights, an extra 1 per cent. dividend could have been paid. This showed the possibility of future receipts, and current might also be bought in the daytime for motive power purposes.

In reply to Mr. J. King, **Major-General Webber** stated that part of the plant of the Cadogan station had been found useful, but it had been bought under the expectation of less than a moiety being of any service.

The motion was then put and adopted unanimously.

The retiring directors, Mr. J. Irving Courtenay and Mr. Nugent Daniell, were re-elected on the motion of Mr. Emile Garcke, seconded by Mr. J. King. Messrs. Cooper Bros. and Co. were reappointed auditors, their fee being increased from 25 guineas to 35 guineas.

In acknowledging a vote of thanks, the **Chairman** said that it had been a long pull to get the Company through, but he hoped they had now reached a secure position.

CHARING CROSS AND STRAND ELECTRICITY SUPPLY CORPORATION, LIMITED.

Directors: G. H. Brougham Glazier, Esq., 7, St. James's-street, S.W., chairman; Richard Chadwick, Esq., 34, St. Martin's-lane, W.C.; I. P. Mendoza, Esq., 4A, King-street, St. James's, S.W.; Agostino Gatti, Esq., and Stefano Gatti, Esq, 436, Strand, managing directors. General manager and secretary: E. Wilmot Seale, Esq. Chief engineer: W. H. Patchell, A.M.I.C.E, M.I.E.E.

Directors' Report.

The directors have to announce to the shareholders with very great regret the death of their chairman, the late Mr. Spencer Chadwick. Mr. George H. Brougham Glazier, the deputy chairman, has been chosen to fill the office of chairman, and Mr. Richard Chadwick (brother of the late Mr. Spencer Chadwick) has been elected a director until the ordinary general meeting. The Corporation was on December 31, 1893, supplying energy to 34,570 8-c.p. lamps, an increase of 17½ per cent. on the number supplied at the end of the year 1892. With the mains added during the past year, there are now upwards of 19½ miles laid. Two actions were brought against the Corporation for injunctions and damages, both of which resulted in judgments in favour of the Corporation on all points with costs The directors have given special attention to the question of maintenance, renewals, and repairs, and have expended a considerable sum in keeping the station in all respects in a very high state of efficiency; they have written £200 off preliminary expenses, made provision for bad debts, carried £700 to depreciation account, £200 to reserve fund, and carried forward £43. 0s. 1d. The net earnings during the past year amounted to £8,654. 8s. 4d; £2,685. 8s. 5d has been paid in respect of interest on debentures up to December 31, 1893, and £3,648. 7s. 11d. was distributed in payment of an interim dividend for the half-year ended June 30, 1893. A sum of £2,955. 10s. 1d. now remains, which the directors propose to deal with as follows: To payment of a dividend of 4½ per cent. for the

year 1893 (less tax)	£6,560	17	11
Interim dividend paid August, 1893	3,648	7	11
	2,912	10	0
Carried forward	43	0	1
	£2,955	10	1

Mr. Agostino Gatti and Mr. Stefano Gatti, the managing directors, are the directors who retire by rotation, and being eligible, offer themselves for re-election. Mr. Richard Chadwick being eligible also offers himself for re election as a director. The auditors, Messrs. O. R. Johnson and Son, also retire and offer themselves for re-election.

Dr. Capital Account Year ending Dec. 31, 1893.	£	s.	d.
Purchase of generating station, mains, lands, buildings, and acquisitions of rights, including law charges in connection therewith	121,828	10	2
Additional expenditure on buildings	17,489	15	0
Machinery	22,401	9	8
Mains (including cost of laying the mains)	35,147	11	10
Meters, and fees for certifying under the Act	2,158	11	4
Electrical instruments, connections, etc.	1,744	5	2
Lamps	43	5	0

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	£	s.	d.
Purchase of patent rights	1,212	4	2
Law costs	2,242	4	6
Plant	882	0	3
Artesian well	1,901	3	6
Office furniture and tools	193	18	11
Total expenditure	£207,244	19	6
Balance of capital account	3 955	0	6
	£211,200	0	0

Cr.	£	s.	d.
Ordinary shares of £5	150,000	0	0
Debentures (5 per cent.)	61,200	0	0
	£211,200	0	0

Note.—The remaining £8,800 of debentures have been applied for, and will be taken up as the circumstances of the Company require.

Dr. Revenue Account Year ending Dec. 31, 1893.	£	s.	d.	£	s.	d.
A.—To Generation of Electricity.						
Coal or other fuel, including dues, carriage, etc.	£4,289	15	0			
Oil, waste, water, and engine-room stores	758	11	7			
Proportion of salaries of engineers, superintendents, and officers	328	10	4			
Wages and gratuities at generating stations	1,566	8	2			
Repairs and maintenance as follows: buildings, £105. 11s. 3d.; engines, boilers, dynamos, motors, etc., and other machinery, instruments, and tools, £1,689. 11s.	1,795	2	3			
Clearing away ashes	120	8	0			
Lighting Company's station	425	11	0			
				9,283	6	4
B.—To Distribution of Electricity.						
Proportion of salaries of superintendents and officers	210	12	0			
Wages and gratuities to linesmen, fitters, labourers	298	16	11			
Repairs, maintenance, and renewals of mains of all classes, including materials and laying the same	67	19	2			
Repairs, maintenance, and renewals of meters, switches, fuses, and other apparatus on consumers' premises	12	9	2			
Way-leaves and licenses	16	10	0			
				606	7	3
C.—To Royalties, etc.						
Royalties, etc., payable for use of patents or patent processes (charged to capital)				—		
D.—To Rents, Rates, and Taxes.						
Rents payable	303	0	0			
Rents, taxes, and repairs	673	7	8			
				976	7	8
E.—To Management Expenses.						
Directors' remuneration	101	17	0			
Salaries of general manager and secretary, accountants, clerks, and messengers	974	10	6			
Stationery and printing	157	7	8			
General establishment charges	149	16	0			
Auditors of Company	52	10	0			
				1 436	1	2
F.—To Law Charges, etc.						
Law expenses				226	9	0
Preliminary expenses				200	0	0
Bad debts account				200	0	0
G.—To Depreciation.						
Depreciation in respect of buildings, plant, machinery, etc.				700	0	0
H.—To Special Charges.						
Stamp duties				19	19	6
Total expenditure				13,649	10	11
Balance carried to net revenue				8,654	8	4
				£22,303	19	3

Cr.	£	s.	d.	£	s.	d.
Sale of current per meter	20,697	19	11			
Sale under contracts	130	0	0			
Amount *per contra* for lighting own station and pumping water	514	9	0			
				21,342	8	11
Rental of meters and other apparatus on consumers' premises	262	3	5			
Sale and repairs of lamps and other apparatus	28	11	8			
				290	15	1
Rents receivable	618	9	8			
Transfer fees	2	15	0			
Discounts	49	10	7			
				670	15	3
				£22,303	19	3

Dr. Net Revenue Account.	£	s.	d.
Interest on debentures accrued to date (less tax)	2,685	8	5
Income tax account	12	0	7
Balance applicable to dividend on ordinary shares	6,603	18	0
	£9,301	7	0

Cr.	£	s.	d.
Balance from last account	4,248	19	11
Less dividend paid	3,759	13	3
	489	6	8
Balance brought from revenue account	8,654	8	4
Directors' fees reserved, 1892, £250; agreed at, £90. 8s.	157	12	0
	£9,301	7	0

General Balance-sheet, Dec. 31, 1893.

Dr. Liabilities.	£	s.	d.
Capital account	211,200	0	0
Sundry tradesmen and others, due on construction of plant and machinery, fuel, stores, etc., to December 31, 1893	3,611	13	1
Sundry creditors on open accounts	3,339	13	2
Net revenue account—balance at credit thereof, £6,603. 18s.; less interim dividend paid to June 30, 1893, £3,648. 7s. 11d.	2,955	10	1
Reserve fund account	219	8	8
Depreciation fund account	700	0	0
	£222,026	5	0

Cr. Assets.	£	s.	d.
Capital account	207,244	19	6
Purchase of premises not used by the Company	5,139	18	0
Stores on hand at December 31, 1893: coal, £105. 4s. 4d.; oils, waste, etc., £19. 6s.; general, £118. 7s. 1d.	242	17	5
Preliminary expenses	1,064	4	4
Sundry debtors for current supplied to December 31, 1893	6,041	15	5
Other debtors	85	9	0
Cash at bankers, £2,202. 2s. 11d.; in hand, £4. 18s. 5d	2,207	1	4
	£222,026	5	0

The annual ordinary general meeting of this Company was held at St. Martin's Town Hall on Tuesday, Mr. G. H. Brougham Glasier occupying the chair.

Before moving the adoption of the report, the **Chairman** expressed his regret at the death of the chairman of the Company, the late Mr. Spencer Chadwick. Continuing, he said that it was satisfactory to note that the Corporation had been successful in two actions brought against them for injunctions and damages. He then moved the adoption of the report, which recommended the payment of a dividend of 4½ per cent., less the interim dividend paid in August last.

Mr. J. P. Mendoza seconded the adoption of the report.

In reply to questions, the **Chairman** explained that the item of £6.041 against sundry debtors for current supplied to December 31, 1893, was due to the accounts being closed with the end of the year. A very large proportion of this amount had now been received. Asked as to why the dividend was only 4½ per cent., as against 5 per cent. in the preceding year, he attributed this mainly to the cutting of the rates by another company having rights in the parish. They had been obliged to lower the charges to be on an equal footing with them to secure customers, and it would have been useless to try and obtain higher rates than the other company. Had it not been for this cutting, a dividend of 6½ or possibly 7 per cent. might have been declared. He, however, believed that this competition in rates would not continue.

The motion was then put to the meeting and agreed to.

Mr. Agostino Gatti and Mr. Stefano Gatti, the managing directors, who retired by rotation, were re-elected, and Mr. Richard Chadwick was re-elected a director.

Messrs. O. R. Johnson and Son were reappointed auditors at a fee of 50 guineas.

DOVER ELECTRIC SUPPLY COMPANY.

The statutory meeting of this Company was held last week at the Company's Office, Castle-street, Dover, Sir William Crundall, J.P., chairman, presiding.

The **Chairman** stated that the meeting was held in compliance with the statute, and, to a certain extent, it was merely formal. The directors had gone to allotment, and a certain number of shares had been allotted; not so many as the directors would have wished, but there had been sufficient shares allotted to go on with the business. The directors would meet directly after this meeting, and would receive and decide tenders for the erection of the works. In conjunction with the works at once to be commenced, they would concurrently begin to lay mains along the roads, so that no time would be lost, and they hoped to begin to supply the current by August or September next. The directors proposed to hold in the course of a few weeks an electrical exhibition in the Town Hall. He thought that so far as Dover was concerned, there was a good prospect in view, as there is every probability of large customers.

A vote of thanks to the chairman terminated the proceedings.

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GUERNSEY RAILWAY COMPANY, LIMITED.

The fifth annual general meeting of this Company was held last week at Hougue-à-la-Perre. A dividend of 2½ per cent. per annum was recommended by the directors to be paid upon the ordinary shares. This provoked some criticism as to the advisability of paying a dividend while the balance-sheet showed a total indebtedness of about £5,000, including debenture, preference, and loan interests due and unpaid to December 31. It was also pointed out that the total interest already to be paid annually, entirely irrespective of any return on the ordinary capital, was, according to the figures of the balance-sheet, about £700, but the motion was supported by several shareholders on the ground that the payment of a small dividend would act as an inducement to the shareholders to take up the remaining portion of the authorised capital. Subsequently the shareholders inspected the machinery and plant, and afterwards were conveyed to town by a special car.

COMPANIES' REPORTS.

SCARBOROUGH ELECTRIC SUPPLY COMPANY, LIMITED.

Directors: Lieutenant-Colonel R. F. Steble, chairman; G. Alderson-Smith, Esq.; John Dale, Esq.; John Woodall Woodall, Esq.; George Lord Beeforth, Esq.; John Bell Simpson, Esq.; the Hon. Charles A. Parsons; A. A. Campbell Swinton, Esq., managing director.

Report of the directors to be presented to the shareholders at the second ordinary meeting to be held at the offices of the Company on Thursday, March 1, at 11 a.m.

The directors have pleasure in reporting that the Company's electric supply station is now in full working order, that the business of the Company is steadily increasing, and that its prospects are most encouraging. On September 1 last, when the regular supply of electricity was commenced, there were connected to the Company's mains 468 8-c.p. lamps. By December 31 this number had increased to 4,114, and at the date of this report to 4,489. By the end of March it is anticipated that nearly 6,000 lamps will be connected. The present capacity of the generating plant provides for about 10,000 lamps, and it is therefore expected that the works will be fully employed before long. Seeing that it would have been inexpedient to commence a profit and loss account with only a small portion of the machinery at work, the directors have deemed it advisable to place all receipts up to December 31 to the credit of formation and preliminary management account. Mr. G. L. Beeforth, the Hon. C. A. Parsons, and Mr. G. Alderson-Smith retire by rotation, but are eligible and offer themselves for re-election as directors. The auditor, Mr. C. E. Bradley, C.A., also offers himself for re-election.

BALANCE-SHEET ON DEC. 31, 1893.

Liabilities.	£	s.	d.
Capital—Nominal, 5,000 shares of £10 each	50,000	0	0
Subscribed, 2,420 shares, on which there has been called up £8 per share	19,360	0	0
Deduct calls in arrears	16	0	0
	19,344	0	0
Bank balances—Woodall, Hebden, and Co., "wages account," overdrawn... £507 8 11			
Deduct "general account" in credit 85 1 7			
422 7 4			
Less Lambton and Co., Newcastle, account in credit 44 0 0			
	378	7	4
Sundry creditors	1,904	6	1½
	£21,626	13	5½

Assets.	£	s.	d.
Capital expenditure—Lands	1,625	4	1
Buildings	3,341	11	4½
Machinery	7,934	9	8
Mains	5,445	8	3½
Transformers, meters, electrical instruments, tools, arc lamp, telephone, etc.	1,595	1	9
Paid to Corporation of Scarborough for provisional order, etc.	525	0	0
	20,466	15	2
Office furniture, fittings, etc.	129	1	3½
Stock of stationery, books, maps, etc.	20	0	0
Stock of lamps	13	15	0
Sundry debtors	384	16	3
Formation, preliminary, and management expenses, etc.—less amount received for current, rent of meters, bank interest, and sundries	612	5	9
	£21,626	13	5½

Electrical Engineering in Australia.—According to *Industries*, the city of Launceston, Tasmania, has accepted contracts for the lighting of the streets by electricity, and the work is expected to be completed by the end of June. Seven tenders in all were received, ranging from that of Messrs. W. T. Glover and Co., of London, for £10,119, to the tender of the Electric Construction Company, Wolverhampton, for £38,335. The city surveyor has also been instructed to submit his views as to the best route for a tramcar service for the city.

BUSINESS NOTES.

Aberdeen.—It appears that the pillars in Union-street for electric lighting cost £4. 10s. each.

Personal.—The address of Mr. E. C. B. Tudor, engineer and surveyor, is now West House, Goole.

Western and Brazilian Telegraph Company.—The receipts for the week ended February 16 were £3,287.

Liverpool Overhead Railway.—The traffic receipts of this railway for the week ending 18th inst. amounted to £671.

Yarmouth.—The Town Council have accepted the tender of Mr. J. F. W. Bray to construct an electric lighting station for £2,620.

West India and Panama Telegraph Company.—The receipts of this Company for the half-month ended February 15 were £2,615, as against £3,009.

Fleetwood.—At a meeting of the Improvement Commissioners the clerk mentioned that certain slight alterations made would enable the Brush Company to complete the plans straight away.

Lighting of Engineering Works.—The engineering works recently acquired by Messrs. Baird, Thompson, and Co., almost opposite to the Agricultural Hall, Islington, N., are to be lighted by electricity.

Tenders for Ballymena (Ireland).—As mentioned in our last issue, tenders are invited by the 3rd proximo for lighting the town, either by gas or electricity, from August 16, 1894, until May 16, 1895, for the Town Council.

Ayr.—The Town Council have had outlined two schemes for lighting the town by electricity, the initial cost being between £16,000 and £18,000. The Council have agreed to get a further report regarding the matter.

Telephony.—The police stations at Cowbridge, St. Nicholas, Penarth, and Barry Dock have just been connected by means of telephonic communication, St. Nicholas serving as a kind of private exchange between the different places named.

City and South London Railway.—The receipts of the Company for the week ending February 18 were £938, against £938 for the same period last year. The total receipts for the first half-year of 1894 show a decrease of £135 compared with those for the corresponding period of 1893.

The Islington Tenders.—As stated fully in our last issue, the Vestry of St. Mary, Islington, invite tenders by March 21 for supplying and erecting the necessary plant and machinery for the supply of electricity in the parish, and for supplying the conduits and mains, which will be laid by the Vestry.

Withdrawal from Partnership.—Messrs. Wm. Peto and Radford inform us that they have purchased from Mr. Charles H. Cathcart his entire share and rights in the firm of Messrs. Cathcart, Peto, and Radford, and that they intend to carry on the firm as before, under the title of Messrs. Peto and Radford.

Lavatory Ventilation.—The two large underground lavatories at the London and Westminster Bank head office are now ventilated by means of an electrically-driven fan, run off the generating plant used for lighting the bank. This ventilating work was carried out by Messrs. Allpress and Co., of 55, Victoria-street, Westminster.

Halifax.—It is suggested that the Corporation, which is about to erect a central electric lighting station, should make a trial of the Livet process of generating power by the combustion of rubbish, and to which reference was made in our last issue. It is said to be understood that the Electric Lighting Committee will put down one of the Livet furnaces as an experiment.

Office-Lighting at Burnley.—The clerk to the Board of Guardians mentioned at a meeting last week that the Finance Committee had met that morning, and resolved to recommend the Board to light certain of the rooms in that building with the electric light, and to accept a tender at an estimated cost of £45. The proposition that Mr. Fletcher's tender be accepted was carried.

Tenders Wanted for Bury.—As stated in our advertisement columns, the Technical School Committee of the Corporation of Bury invite tenders for the supply of electric light fittings, including switchboards, lamps, wiring, etc., for lighting the technical school now in course of construction in Broad-street, Bury. Tenders to be delivered to the borough engineer by March 10.

Newcastle.—The Board of Guardians have agreed that the Workhouse Committee should obtain the opinion of an expert as to the probable cost of illuminating the workhouse by electricity. The electric lighting of Eldon-buildings (whichare now being erected on an important site in Newcastle-on-Tyne) is being carried out by Messrs. Allpress and Co., of 55, Victoria-street, Westminster.

Electric Tramway at Reading.—The tramways company contemplate applying to the Corporation of Reading for permission to lay down an electric tramway shortly. The company hope to adopt the overhead system, which Mr. J. Clifton Robinson, C.E., the manager of the Southern Tramways Company, a gentleman also interested in the Reading tramway, has persuaded the Bristol Company to introduce.

Adjustable or "Perfect" Pendant.—Reports having been spread that the patent term of this well-known fitting had expired, Messrs. Faraday and Son, of 3, Berners-street, W., think it worth while to make known that the renewal conditions have been periodically complied with. They hold exclusive rights

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from the patentee to manufacture, and many years must elapse before the patent becomes void.

Morecambe Electric Light and Power Company.—The revenue account from November 16, 1892, to December 31, 1893, shows an expenditure of £1,361, and revenue £1,546, leaving a gross profit of £189, reduced by £92 for interest on borrowed capital and bad debts (£9), leaving a balance of £88, which the directors recommend to be applied to the payment of a dividend of 2 per cent. per annum on the paid-up share capital.

Wiring Tenders Required — Tenders are required for the electric light wiring of the town hall in course of erection at Morley (Yorks.). Specifications, plans, and particulars may be obtained from Messrs. Holtom and Fox, architects, Dewsbury, on deposit of £1, which will be returned on receipt of a *bonâ fide* tender. Sealed tenders, endorsed "Wiring," to be sent in to Mr. R. Borrough Hopkins, town clerk, Morley, by 26th inst.

Keighley.—At a meeting of the Town Council this week Mr. Foulds asked, in regard to the proposal to apply for powers to provide the electric light, whether it had been definitely settled to make an installation, and suggested that a separate committee should be constituted to deal with the subject. It was explained that the present steps were only provisional, and that due notice would have to be given before powers were applied for.

The Brush Company's Dividend.—The directors of the Brush Electrical Engineering Company, Limited, have declared an interim dividend at the rate of 6 per cent. per annum on the preference shares, and at the rate of 5 per cent. (the maximum which, according to the articles of association, can be paid on an interim dividend) on the ordinary shares of the Company for the six months ended December 31, 1893, payable March 1, 1894.

Penistone.—At a meeting of the Local Board the clerk read a letter from the Electrical Engineering Company, Limited. The letter pointed out that they had carefully examined the map and general conditions furnished by the Board, and had come to the conclusion that it was not practicable to submit a scheme of lighting by electricity a total of less than 200 lamps of 16 c.p., distributed over 4¼ miles of road, which would be a commercial success.

Edinburgh.—The Cleaning and Lighting Committee of the Town Council made recommendations on Tuesday on the subject of electric lighting: (1) that if four of the 160 lamps already authorised for the first installation in the city were available, the Lawnmarket should be lighted by electricity; (2) that no action should be taken in the meantime as to the lighting of George-street and St. Andrew-square and the cross streets from Princes-street with electricity. The recommendations were approved.

Tenders for Harrogate.—As well be seen from our advertisement columns, the Corporation of Harrogate invite tenders for the following plant in connection with the proposed electricity works: refuse sorting and drying plant, with accessories, steam-boilers and accessories, steam and exhaust pipes, transformers and accessories, distribution mains. Specifications for all or any section may be obtained on application to Mr. Samuel Stead, borough surveyor, Municipal Offices, Harrogate, on payment of £1. 1s. Tenders must be sent in by March 14.

A Cornish Boiler Required.—Tenders are invited by the 26th inst. for the supply of a Cornish boiler for the electric light station, Abercorn Basin, for the Belfast Harbour Commissioners. Copies of specification, forms of tender, and any further information required may be obtained from the harbour engineer, Mr. G. F. L. Giles. Sealed tenders, on the special forms provided for the purpose (accompanied by drawings), to be addressed to Mr. A. W. Currie, secretary, Harbour Office, Belfast, endorsed "Tender for Boiler," and sent in by 26th inst.

Ince.—The second meeting of the Gas Enquiry Committee of the Local Board was held on the 26th ult. Some discussion took place as to the adoption of the electric light for street and general lighting. It was agreed to make enquiries at places where electricity is employed as to the cost and advantages of the system, and for this purpose representatives are to be appointed to visit the districts where information on the matter can be obtained. It was decided to hold a meeting on March 2 to receive the reports of the deputation.

Sheffield.—The Improvement Committee of Sheffield City Council on Monday passed the following resolution: "That provision be made for a supply of electricity throughout the new Town Hall, and for a modified supply of gas to light the corridors and staircases; that the architect be requested to report to what extent this modification of gas supply will reduce the contract; and also to report whether, in his opinion, it would be desirable to dispense with gas altogether, and in that case what further reduction would be effected."

Insulated Cables Required.—Tenders are invited by the 26th inst. for providing and fixing, in lieu of existing wires, insulated cables for electric lighting purposes, on portions of their property, for the Swansea Harbour Trustees. Particulars, information, and forms of tender may be obtained on application to the Trustees' engineer, Mr. A. J. Schenk. Tenders, addressed to Mr. Talfourd Strick, clerk, Harbour Offices, Swansea, and marked on the outside "Tender—Electric Lighting," should be delivered at the Harbour Offices, Swansea, by the date mentioned.

Tenders for St. Pancras.—The St. Pancras Vestry invite, as stated in our advertisement columns, tenders for the following works: (1) Lancashire boilers, economiser, feed pumps, etc.; (2) engines, dynamos, condensing plant, etc. The drawings can be inspected, and copies of the specifications, bills of quantities, and general conditions can be obtained at the offices of Prof. Henry Robinson, C.E., 13, Victoria-street, Westminster, on payment of 10s. for each. Tenders are to be sent in to Mr. Albert E. Pycraft, chief clerk, Electricity and Public Lighting Department, Vestry Hall, Pancras-road, N., by March 5.

Wakefield.—The committee having in hand the question of electric lighting met on the 22nd ult. The town clerk read letters from Messrs. Harrison, Beaumont, and Smith, acting on behalf of the Wakefield Union Rural Sanitary Authority, requesting to have a clause inserted in the electric lighting provisional order to the effect that without the consent in writing of that Authority, the Corporation should not, either directly or indirectly, supply energy or power within the Authority's district, and forwarding draft of clause as proposed by them. The committee resolved to object to the insertion of such clause in the order, and the town clerk has been instructed to oppose its insertion.

Tenders Required for Edinburgh.—The Corporation of Edinburgh invite tenders, as stated in our advertisement columns, for the following work in connection with the electric lighting of the city: Contract No. 5, construction of concrete culverts and laying of stoneware and iron pipes and casings; No. 6, supply of cast-iron pipes, casings, and road service boxes; No. 7, supply of stoneware casings and insulators; No. 8, supply of copper strip; No. 9, supply of armoured and unarmoured insulated cable. All information will be supplied by Prof. Alex. B. W. Kennedy, the consulting electrical engineer to the Corporation, at his office, 14, Old Queen-street, Westminster, London, S.W.

Telegraph Construction and Maintenance Company.—The report for 1893 states that the accounts show a net profit of £99,435, after charging the interest on the debentures. To this is added £41,433 brought forward from 1892, making a total of £140,868. From this sum is deducted the interim dividend of 5 per cent., paid in July, amounting to £22,410, leaving £118,458 to be dealt with. It is proposed to distribute a dividend of £1. 16s. per share, absorbing £67,230, being at the rate of 15s. per cent., and making, with the amount already paid, a total dividend for the year of £2. 8s. per share, or 20 per cent., free of income tax, leaving £51,228 to be carried forward to the next account.

Hanley.—The Electric Lighting Sub-Committee of the Town Council have recommended that various tenders, amounting to £207. 10s., be accepted for instruments and tools, and other tenders, amounting to £1,000, for meters, switches, cables, fuses, and general stores; also the tenders of Messrs. Spagnoletti and Crookes for the electric wiring and fittings required in the Corporation buildings, amounting to £3,034. 14s. 1d. This sum is divided as follows: Town Hall and Victoria Hall, £1,408; free library and boys' reading-room, £129; museum and technical schools, £155; public baths, £144; market hall and fish market, £878; butchers' market, £176; the electricity works, £110. The recommendations have been adopted.

Electro-Chemical Company, Limited.—This Company has been registered with a capital of £200,000, divided into 26,000 £10 per cent. preference and 14,000 ordinary shares of £5 each. The object is to acquire from the Electrolytic Caustic Soda and Chlorine Trust Limited, British patent No. 2,296 of 1890, for improvements in the electrolytic production of caustic soda, caustic potash, and other products from their salts, and other patents for inventions relating to electrolytic and electro-chemical operations and apparatus therefor; to manufacture, prepare, sell, and deal in caustic soda, caustic potash, sulphuric and hydrochloric acids, etc. The first signatories are Messrs. Lewis Evans, Leopold Field, Thos. M. Dunster, Wm. S. Wakefield, Wm. G. Taylor, Thos. Hitchcock, Randal Vogan.

Tynemouth.—On Wednesday the Trade and Commerce Committee of the Town Council reported that the borough surveyor had submitted to them a report of a sub-committee in reference to electric lighting in the borough. The sub-committee's report stated that Messrs. C. A. Parsons and Co. only had tendered for the carrying out of such works as were necessary to retain the powers conferred by the provisional order; that the tender for laying electric mains in Saville and Howard streets amounted to £1,355; for a dynamo which will energise 700 10-c.p. lamps, £445; and for lighting the Town Hall Buildings, £162; making a total of £1,962. The sub-committee recommended that application be made to the Local Government Board for sanction to borrow £2,000 to carry out the scheme, but that only £1,355 for electric cables be expended at present. The report was adopted.

Presentations.—Mr. Cutler, assistant engineer at the Bath Electric Light Works, has been presented with a handsome barometer by Mr. F. Hallows, on behalf of the staff, on the occasion of his resignation as assistant engineer. On Saturday a large company assembled at the Park Hotel, De Grey-street, Newcastle, the occasion being a presentation to Mr. Jos. Askew, who has been employed as a foreman in the Elswick Ordnance Works for upwards of 15 years, and who is leaving to fulfil an important situation in the electrical engineering works of the Fowler Waring Cables Company, North Woolwich. The presentation, which consisted of a handsome gold watch, was made by Mr. Curry. Mr. Arthur Watts, local manager of the National Telephone Company's Newcastle district, was the recipient the other evening of a handsome silver tea and coffee service, presented by the local staff.

Lighting of Newspaper Offices.—The offices of the *Morning* newspaper are to be lighted by electricity, and Messrs. Drake and Gorham have been commissioned to carry out the work. The plant will consist of a Crossley "Otto" high-speed gas-engine of 14 brake horse-power, fitted with patent tube ignition and the latest improvements. The generator will be an Electric Construction Company dynamo wound for 90 amperes at

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105 volts for direct running. Spring contact main switches, the patents for which are held by the firm, will be adopted. The lights at present to be arranged for are 140, but this number will probably be increased later on to 200. A special bracket for outside use has been designed by the firm for carrying an arc lamp containing a device of the *Morning*. In addition to the electric light installation, a complete system of electric bells is being fitted.

Ossett.—On Monday a meeting was held at the Ossett Technical School, convened by resolution of the Ossett Tradesmen's Association, to take into consideration the price and quality of the gas supplied to Ossett and Horbury by the Ossett Gas Company. Mr. Frankland mentioned that, as the electric light was the light of the future, the town ought not to be saddled with the gas plant. The ex-Mayor (Mr. F. L. Fothergill) stated that, in consequence of the quality and price of the gas, he had recently followed the example of two other millowners in the borough by putting down an electric lighting plant. The Ossett Co-operative Society would, he believed, shortly do the same thing unless some alteration was made. An application was also intended to be made for a provisional order authorising the supply of electricity for lighting purposes in Ossett, and that application would go forward unless the Corporation made a similar one.

Llandudno.—The engineer to the Improvement Commissioners reported on Wednesday that he and the gas manager had looked into the question of supplying an additional six millions of gas per annum to the proposed electric light company, and he estimated that in case the electric light would be well received it would make a difference in the output of gas to the extent of one and a half millions. The Gas Committee recommended that the Board sanction the scheme for the proposed electric lighting, and consent to the application by the company for a provisional order, satisfactory terms being first agreed upon with respect to the sale to the Commissioners with a specified time of the undertaking, the committee to at once enter into negotiations with the promoters. On the motion of Mr. Elias Jones, the electric light and water-supply questions were referred to a committee of the whole Board and the promoters of the company.

Lighting in the City.—At a meeting on Tuesday of the Commissioners of Sewers, Mr. Burmester, the chairman of the Streets Committee, presented a report on the subject of an application by Mr. Bibra, of the Champion Hotel, 15, Aldersgate street, to erect two standard electric lamps on the kerb in front of his premises, and recommended that the application should not be complied with. Mr. Deputy Dowling moved as an amendment that the application should be complied with. Mr. Deputy White, in seconding the amendment, said he thought some consideration should be given to the fact that the applicant had spent between £3,000 and £4,000 on improvements at the Champion Hotel. Eventually, the application was referred back to the committee At the same meeting, Mr. King enquired whether anything had been done on the question as to the appointment of an electric light inspector. In reply, Mr. Burmester stated that the matter had been referred by the committee to Mr. W. H. Preece, and a report on the subject would be shortly presented to the Court.

Lighting in Jersey.—At a States meeting an Act of the committee for the lighting of the town of St. Helier with respect to the illumination of the town was read. There had been communication from the Aurora Electric Lighting Company, which offered to supply light at certain fixed charges, but the committee had come to no conclusion on the matter. The Constable of St. Helier thought they should also discuss at the same time a petition concerning electric lighting in Jersey from Messrs. Allbright, Grand, Binet, Howell, and Hoyle, of London; also a bill thereon, and correspondence as to the protection of telegraph wires, etc. He thought it would be better to refer all three documents, which really formed one subject, to a committee which would seriously consider the same. The Deputy of St. Saviour pointed out that these certain petitioners asked for a 42 years' concession and the right to sell the same. The Rector of Grouville said the Asylum Committee was thinking of lighting the institution by electricity. Why not refer the subject to them? The matters were referred ultimately to a special committee.

Birmingham Market Hall.—On Tuesday, at a meeting of the City Council, Mr. Parkes moved that the scheme (to which reference was made in our issue of the 9th inst.) for lighting the Market Hall by electricity be adopted, and that the Finance Committee be instructed to borrow £1,000 for providing the necessary lamps, fittings, etc. He explained that for some time past the lighting of the market had been very unsatisfactory. He had to make what, he said, might be regarded as a startling statement—namely, that the electricity would come out cheaper than gas. The first reason for this was because of the wasteful character of the gas lighting of the Market Hall, and the second because they had special terms from the electrical supply company. For the £525, which was the estimated cost of the electric light, they would light the outside as well as the inside of the market. Inside there would be 32 lamps, and outside eight lamps—two at the Bull Ring end, two at the Worcester-street end, two in Philip-street, and two in Bell-street. It had been said that the tenants did not desire the electric light, but that was a mistake. The tenants would pay for it as they had paid for the gas. The committee were perfectly prepared to stand by the figures they had given. The motion having been seconded, was adopted after some discussion.

Lighting at Taunton.—It was reported at a meeting of the Town Council last week that the cables had been laid, as arranged with Dr. Fleming, from the No. 1 sub-centre, which is formed under the town clerk's office, and tested to 4,000 volts, and that the transformer would shortly be fixed and at work. The electrical engineer reported that, with the assistance of the borough surveyor, they had laid the low-tension network and feeders, and were laying the high-tension cable for the first sub-station They had received the Davey-Paxman "Economic" boiler. Since December 17 one-half of the public arc lamps had been alight until 6.30 a.m. They had fixed meters on all the larger consumers' mains, and were awaiting Dr. Fleming's report on the small meters to obtain and fix them. The Electric Lighting Committee stated that a letter had been received from Messrs. Newton, offering to make a 30 kilowatt transformer, and to let the Council have it on loan; also to make and send a second transformer to the same specification to Dr. Fleming to test, on the understanding that if they proved satisfactory the Council would purchase both of them as soon as it is decided to start another sub-station, at the price of £183 each. The committee recommended that their offer be accepted. The committee asked the Council to empower them to accept Messrs. Babcock and Wilcox's estimate for cross drains and the steam-piping necessary to connect them with the engines and boilers at the electric lighting station, at the price of £170, subject to the approval of Dr. Fleming. These reports were adopted.

Lighting at Maidstone.—The Electric Lighting Committee of the Local Board reported last week that they had considered the schemes and proposals submitted to the Board by various companies and private individuals for taking over the Maidstone electric lighting order, and that they were of opinion that those of Messrs. Bourne and Grant were the most advantageous. The committee therefore recommended that further negotiations be entered into with that firm with a view to coming to satisfactory terms and arranging for a transfer of the order. Alderman Ellis (chairman of the committee) said that this question had been before the Board from time to time, and now, after inviting proposals from various firms for taking over the electric lighting order, the committee had come to the conclusion that that of Messrs. Bourne and Grant was the most favourable. The offer of Messrs. Bourne and Grant was to supply, not only the streets set down in the order, but a number of other streets. The Authority were to be at liberty to purchase at the end of 21 years, or at the end of another five years, up to the forty-first year, on paying the fair market value as a going concern, and excluding any consideration for future profits, such market value to be obtained by arbitration. Alderman Long thought they ought to have a little more time to consider the matter before voting upon it. He only received a copy of the report the previous night. Mr. Barker supported the adoption of the report, because as a member of the Lighting Committee he felt it was the best thing they could do. Eventually the matter was postponed for a fortnight.

Electric Lighting at Cardiff.—A meeting of the Electric Lighting Committee of the Cardiff Corporation was held on Tuesday, Councillor Vaughan presiding. Alderman Jacobs said that now Mr. Massey, the consulting electrical engineer, was present, he would draw attention to an article which appeared in a local paper suggesting the utilisation of a destructor for the purpose of generating electricity in connection with the lighting of the town. The matter was mentioned to Mr. Massey when they visited the various towns some years ago, and at that time he (Mr. Massey) thought that it would not apply under the circumstances then. They had learned that at Halifax the idea had been a great success. They had been thinking of erecting a refuse destructor in Cardiff, and he thought it would be worth while considering whether they could use the destructor for lighting purposes. Mr. Massey reminded the committee that the use of a destructor had been thought of in all the reports presented to the committee. With regard to the destructor at Halifax, after carefully reading that article in the local paper, and speaking seriously of the schemes, he thought it an attempt to impose upon the British public. Mr. Harpur, the borough engineer, said that in those matters they were continually putting the cart before the horse. It did not follow that because they were erecting electric lighting works that they must erect a destructor as well. Mr. Massey wished it to be understood that his remarks with regard to the imposition on the public referred to Halifax. He intimated that so far 10,329 yards of pipework had been executed. A new system had been created, which would prevent such accidents as occurred at Bournemouth some time ago. The work in connection with the electric lighting is progressing. Three boilers are in place, brick seatings finished, engine and dynamo foundations completed, and floor laid. The travelling crane has been up now for some time, and the condensing apparatus is delivered and ready for erection.

Elmore Guaranteed Dividends.—In the City of London Court, on Monday, before Mr. Commissioner Kerr, the case of McGeagh *v.* Elmore's Foreign and Colonial Patent Copper Depositing Company, Limited, came on for hearing. Mr. H. C. Richards appeared for the plaintiff; the defendant company was unrepresented by counsel. Mr. Richards said his client was induced to take shares in Elmore's French Patent Copper Depositing Company by seeing a statement in the prospectus that a dividend of 10 per cent. would be guaranteed for the first year by Elmore's Foreign and Colonial Patent Copper Depositing Company, and that there would also be a participation in further profits. The amount guaranteed had not been paid. The secretary to the French company (Mr. J. Shurmur) was also secretary to the guaranteeing company, and the defence set up was that the prospectus making the statement was issued without the authority of the guaranteeing company. Mr. Shurmur was then put into the box. Mr. Richards: You were secretary to the guaranteeing company when the prospectus was issued?—Yes. Was that prospectus true when you put your name to it as secre-

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tary?—I believe so. Was that paragraph true that the 10 per cent. had been guaranteed by the Elmore's Foreign and Colonial Company? Quite true. You have paid the guaranteed dividend to a good many of the shareholders?—The French company has. Where has it got the money from?—From the guaranteeing company. Why have you declined to pay Mr. Forster McGeagh?—His shares were of an issue upon which the dividend had not matured at the time we paid those dividends that did mature. In reply to Mr. Commissioner Kerr, witness said the prospectus was not issued actually by the foreign company; they were not responsible for the actual working of it. The Elmores had guaranteed the dividend under certain conditions. Plaintiff's claim, he thought, was amply satisfied by the scheme of resuscitation. Mr. Richards said the case was a test case, and other shareholders were awaiting the result of it before themselves taking action. Mr. Commissioner Kerr (to witness): You must bring the money into the court. Mr. Shurmur: Every other contributory has come into the scheme; they have not been paid their dividends. The case was adjourned for a week.

PROVISIONAL PATENTS, 1894.

FEBRUARY 12.

2990. **Improvements in electric tramways.** Thomas Parker, Tettenhall, Wolverhampton.

3013. **Improvements in apparatus for drawing through electrical or other cables or conductors in underground pipes or conduits.** S. A. Mahood, 4, Bagnall-street, Hanley, Staffordshire.

3020. **Improvements in induction electrical machines.** Frederick Tudsbury, 15, St. James's-row, Sheffield. (Complete specification.)

FEBRUARY 13.

3052. **Improved method of advertising by means of an electric lamp.** John William Ewart, 23, Ampthill-square, London.

3056. **Improvements in and relating to electrical safety fuses.** Alexander Marr, 70, Market-street, Manchester.

3072. **Improvement in arc lamps.** John Edward Woolverton, 154, St. Vincent-street, Glasgow. (Complete specification.)

3079. **An electric bell indicator.** Henry Sanders, 272, Summer-lane, Birmingham.

3080. **Improved method of fixing electric call-bells.** William Paul Theermann, Walter Crookell, and George Christopher Elliott, 2, Great Ducie-street, Manchester.

3101. **Improvements in armatures for dynamo-electric machines.** William Brooks Sayers, Henry Alexander Mavor, William Arthur Coulson, and Samuel Mavor, 46, Lincoln's-inn-fields, London.

3108. **Electric railways.** Paul William Leffler and Charles Eugene Corrigan, 28, Southampton-buildings, Chancery-lane, London. (Complete specification.)

3109. **An electric locomotive for combined adhesion and rack traction.** John Imray, 28, Southampton-buildings, Chancery-lane, London. (Francis Rinecker, Germany.)

3111. **Improvements in electric signalling devices.** Reginald Haddan, 18, Buckingham-street, Strand, London. (Alexander Scott Williams, United States.) (Complete specification.)

3118. **Improvements in the regulation of electric motors.** Illius Augustus Timmis and Alfred Ivor Smith, 2, Great George-street, Westminster.

3125. **Improvements in armature connections for dynamos.** Oza Dufault, 53, Chancery-lane, London.

FEBRUARY 14.

3155. **Combined casings and insulators for electric wires.** William Williams and Thomas Bertram Johnston, 2, John-street, Bristol.

3166. **Improvements in underground conductors of electrical tramways.** John Brierley Howard, Penny Bank-chambers, Halifax. (Wilhelm Simon, Wolfgang Beissbarth, and Julius Beissbarth, Germany.)

3217. **Improvements in electric arc lamps.** Henry Francis Joel, 44, Lavender-grove, Dalston, London.

3223. **Improvements in heating of gases by electricity.** William Donaldson, 1, Queen Victoria-street, London. (Complete specification.)

FEBRUARY 15.

3245. **Improvements in lead-covered electric cables.** David Cook, 30, Lancaster-park, Richmond, Surrey.

3273. **Improvements connected with arc lamps.** Arthur Chester and John James Rathbone, 166, Fleet-street, London. (Complete specification.)

3277. **Improvements in the construction and methods of manufacture of electrical cables.** George Hinde Nisbett, 248, Stanstead-road, Forest Hill, London.

3291. **Improvements in electric arc lamps.** Alfred William Money and Herbert Nash, 23, Southampton-buildings, Chancery-lane, London.

3294. **Improvements in electric lighting apparatus for gas burners.** Mortimer Peterson, 46, Lincoln's-inn-fields, London.

3312. **Improvements in electric arc lamps.** Henry Hayes Cooper and the Electrical Installation Company, Limited, 53, Chancery-lane, London.

FEBRUARY 16.

3363. **Improvements in arc lamps.** Samuel Sealy Allin and William Henry Wood, 52, Woodstock-road, Bedford-park, London.

3376. **Improvements in appliances or means for securing the covers to the casings of electric light wires, applicable also to other purposes.** John Bailey Holroyde, 6, Bank-street, Manchester. (Charles James Holroyde, Australia.)

3384. **Improvements in incandescent electric lamps.** Joseph Walter Turnbull, 77, Chancery-lane, London. (Complete specification.)

FEBRUARY 17.

3422. **Improved method of and means for generating steam by electricity.** William Rockcliffe, 3, St. Nicholas-buildings, Newcastle-on-Tyne.

3426. **Improvements in electric lamps and in the holders or sockets therefor.** David Hunter and William Alexander Jack, 70, Wellington-street, Glasgow.

3450. **An improved flexible and electrically insulating shaft coupling.** William Richard Wynne, 5, New-court, London. (Complete specification.)

3468. **Hygienic safety device or guard for telephones.** Emil Pollak, 28, Southampton-buildings, Chancery-lane, London.

3469. **Improvements in dynamo-electric and electro-dynamic machines.** Paul Pöschmann and Richard Hanisch, 191, Fleet-street, London.

3476. **Improvements in and connected with electric bells.** Howard Blain Little, 115, Cannon-street, London.

SPECIFICATIONS PUBLISHED.

1886.

1999. **Electric lamps.** Swan. (Second edition.)

1889.

10640. **Arc lamps.** Crampton and another. (Second edition.)

1891.

19704. **Application of depolarisers in electrolysis.** Richardson. (Second edition.)

1892.

18039. **Electrolytic cells, etc.** Hargreaves and Bird. (Second edition.)

19194. **Telephones.** Langdon-Davies.

21480. **Measuring electricity.** Anders and Kottgen.

1893.

2267. **Electrolytical separation of bases of salts, etc., from saline solutions.** Vautin.

4938. **Incandescent electric lamps.** Ram.

5684. **Electric primary batteries** Tuckerman and Mackenzie.

5844. **Storage batteries.** Thompson. (Hartung.)

6032. **Switches for electric light fixtures.** Mills. (Hutchinson.)

6050. **Alternate-current motors.** Bláthy and Déri.

6439. **Electric switches.** Marsh

6613 **Boxes for electric transformers.** Parsons and Willis.

6642. **Socket shank of electric lamp.** Mather and Kemp-Welch.

6666. **Distributing electricity.** Geipel.

20799 **Electric incandescent lamps.** Hartogh.

22956. **Electro-positive electrodes.** C. A. J. H. and H. E. R. Schroeder.

23424. **Incandescent electric lamps.** Green.

24607. **Electric switches, etc.** Claremont.

24608. **Fixing flywheels to pulleys of dynamo-electric motors, etc.** Claremont.

24865. **Electric wire insulators** Lake. (Rand.)

24867. **Electric railways.** Love and Gallatin.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	2⅜
— Pref.	—	2¼
Charing Cross and Strand	—	5
City of London	—	11½
— Pref.	—	13
Electric Construction	—	1¾
House-to-House	5	2
India Rubber, Gutta Percha & Telegraph Co.	10	24½
Liverpool Electric Supply	5	6¼
	4½	5½
London Electric Supply	5	1
Metropolitan Electric Supply	—	8¾
National Telephone	5	4¾
St. James', Pref.	—	6⅝
Swan United	3½	3¾
Westminster Electric	—	5½

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NOTES.

Prof. Tyndall's Will.—The value has been sworn at £21,866 of the personal estate of Prof. John Tyndall, who died on December 4 last.

Private Bill Legislation.—The Bills dealing with the Central London, and Charing Cross, Euston, and Hampstead Electric Railways will first come before the Commons.

Liverpool.—The Liverpool Electric Supply Company had connected to the mains on December 31 last 25,784 16-c.p. lamps, as against 20,254 lamps at the end of the previous year.

"Street Railway Journal."—The offices of the *Street Railway Journal* have been removed from the World Building to the Havemeyer Building, 26, Cortlandt-street, New York City.

Lighting of Omnibuses.—A new competitor in the field of lighting omnibuses by electricity has just made his appearance in the Metropolis, and to which reference is made in another column.

Croydon.—The Croydon County Council on Monday referred back to committee a motion that application be made to the Local Government Board for sanction to borrow £25,000 for electric lighting purposes.

Students of the Institution.—A students' meeting of the Institution of Electrical Engineers will be held this (Friday) evening at 28, Victoria-street, Westminster. Mr. E. H. Bowyer will read a paper on "Lightning."

The Institution.—The note by Mr. Mordey on "Parallel Working through Long Lines," the reading of which was postponed on the 22nd ult., will be presented at a meeting of the Institution on Thursday next, the 8th inst.

Communication between Passengers and Train Staff.—The Great Indian Peninsula Railway authorities have recently tried on local trains an electrical system designed for this purpose by their late telegraph superintendent, Mr. A. R. Simkins.

Book Received.—A copy of "The Engineer's Year-Book of Formulæ, Rules, Tables, Data, and Memoranda in Civil, Mechanical, Electrical, Marine, and Mine Engineering," by Mr. H. R. Kempe, A.M.I.C.E., M.I.E.E., has reached us from Messrs. Crosby Lockwood and Son."

Electrical Specialities.—A list of electrical specialities has been issued by Messrs. Miller and Woods, of 2, Gray's-inn-road, W.C. The list deals with transformers for heating medical cauteries, sub-divided transformers, lamp water (coffee) heaters, medical battery boxes, etc.

Crystal Palace Order.—With regard to the Crystal Palace and district electric lighting provisional order, which is practically in substitution for the license recently granted to the company extending its area of supply, the London County Council have decided to take no action in the matter.

Lighting Cold-Air Stores.—The extensive cold-air stores now being erected in Water-street for the Manchester Corporation at a cost of £100,000, are to be lighted by electricity produced by generators laid down on the premises. In addition to this, electric motors will be used for driving fans for circulating air throughout the buildings.

The Junior Engineering Society.—The fifth ordinary meeting will take place on Friday evening, the 9th inst., at the Westminster Palace Hotel, Victoria-street, S.W. The paper to be read and discussed is on "The Design, Construction, and Working of Boilers for Locomotive Engines," by Mr. G. Frank Burtt, G.I.Mech.E., member.

Traction at Bristol.—The Bristol Town Council on Tuesday sanctioned a proposed tram extension, which the Bristol Tramways and Carriage Company are undertaking at a cost of £50,000. The new branch will extend 3½ miles to St. George, which has a population of 70,000 people. Overhead electric wires will be used on the same principle as at Walsall.

The Victoria Embankment.—The London County Council postponed on Tuesday the Highways Committee's recommendation that the Victoria-embankment should be lighted from the centre of the roadway, the work to be carried out by the Works Committee. This matter had previously been referred back to the committee for reconsideration, as stated in our issue of the 16th ult.

City Lamp Figures.—At the beginning of 1893 the City of London Electric Lighting Company had 20,241 lamps connected to the system, with a current-supplying capacity equal to 32,000 lamps; in the middle of the year the figures were respectively 45,919 and 34,000; at the end of the year, 65,341 and 64,000; and at the present moment the figures are respectively 76,000 and 100,000.

Communication between Lightships and the Shore.—The land wires for the connection of the North Sands Head lightship on the Goodwins with the shore are completed, and nothing now remains to be done but to run the cable from the lightship to the shore at Ramsgate, a distance of about five miles. A telephone similar to those used in the postal service will be fitted up on the lightship.

Electrical Standards Committee.—A meeting of the Electrical Standards Committee was held last week at the Board of Trade, at which the following members were present: Sir Courtenay Boyle (in the chair), Mr. F. J. Hopwood, Major Cardew, Lord Kelvin, Mr. W. H. Preece, Lord Rayleigh, Prof. G. Carey Foster, Mr. R. T. Glazebrook, Dr. John Hopkinson, Prof. W. E. Ayrton, and Sir T. W. P. Blomefield, secretary.

Lighting in Notting Hill.—The directors of the Notting Hill Electric Lighting Company state that the prime cost of the generation of current during the second half of last year was lower than that appearing in any of the accounts of other London companies for 1893. The company has now been placed on a dividend-earning basis. The number of houses supplied has increased from 124 in 1892 to 173 in 1893, and the number of lights from 9,438 to 12,153 respectively.

Extensions of Mains.—The London County Council have sanctioned the laying by the House-to-House Electric Light Supply Company of mains in a part of Evelyn-gardens and on the east side of Drayton-gardens; by the Kensington and Knightsbridge Electric Lighting Company, of mains in Egerton-gardens and St. Michael's-grove; by the Westminster Electric Supply Corporation, of mains across Belgrave-road; and by the Charing Cross and Strand Electricity Supply Corporation, of mains in Green-street.

Electric to Compete with Steam Railways.—It is probable that the cities of Washington and Baltimore will soon be united by an electric railway in addition to the ordinary railways in existence. Work on this new line has commenced. The distance is about 35 miles. It is the purpose of the company to equip the line with model vestibule trains, making the journey in an hour, and charging one dollar for the round trip; that is, the same fare that is charged for the single journey by the steam railways.

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Signalling between Ships at Night.—With a view to overcome the difficulties experienced in distinguishing between long and short flashes with incandescent lamps arranged on mastheads, experiments have been carried out in the "Undaunted," cruiser, and the "Hecla," torpedo storeship, with lamps in which each globe contained several filaments. The naval electrical experts are now reported to have invented a lamp, to be known as the multiple-fibre lamp, by which all difficulties are overcome, and the Admiralty have ordered all ships in the service larger than third-class cruisers to be supplied with these lamps.

Telegraphy in South Africa.—The British South Africa Company have been informed that a telegraph office has been opened at Tati, on the Matabeleland border. Information has been received at Cape Town that the Portuguese officials, acting on instructions from Lisbon, threaten to oppose the construction of telegraph lines between the British spheres of influence and Tete, on the Zambesi. This is the route which, it was intended, should be followed by the sections of Mr. Rhodes's projected overland telegraph line, to connect Matabeleland to the south of Portuguese Zambesia with Nyasaland to the north.

"The Book of the Fair."—Under this title the Bancroft Company, Auditorium Building, Chicago, are reproducing in book form, in the highest style of art, the features of the recent Chicago Exhibition. The book traces the evolution of the fair in all details, shows how it was built, who were its chief founders, and then pictures it not only in its general but in its special features. The book, which is being issued in 25 parts, at the price of one dollar each, will not be complete until the end of the summer. Two parts, Nos. 10 and 11, referring to the electrical section, have reached us. The illustrations are of the high-class kind characteristic of American ingenuity.

Transmission of Power.—This subject is engaging more attention every day, and the pamphlet issued by the Westinghouse Electric Company, Limited, entitled "Transmission of Power," comes at an opportune moment. Whilst this *brochure* is essentially a description of systems and apparatus furnished by the Westinghouse Company, the author (Mr. L. B. Stillwell) has embodied in it valuable information concerning the direct and alternating current systems of distribution. The numerous illustrations are excellent. The Tesla polyphase system is also fully illustrated and described, and the pamphlet concludes with details of auxiliary apparatus and switchboard instruments.

The Douglas Tramway.—It is reported that the directors of the Isle of Man Tramway Company have recommended the shareholders to accept an offer from the Douglas and Laxey Electric Tramway Company to purchase their property for £38,000. They point out that four years hence the Douglas Commissioners have power to acquire the undertaking at the then value, exclusive of all allowance for past or future profits or compensation. In the face of this statement, it is difficult to understand why the electric tramway company wish to acquire the line. If the Commissioners, as stated, may compulsorily take possession of the tramway in four years, how is the line to prove a commercial undertaking to the proposed new owners?

The Aberdeen Central Station.—As foreshadowed in our last issue, this central station was set in operation on Tuesday. The ceremony of turning on the light took place in the Joint Town and County Hall, and was performed by Mrs. Stewart. The works now completed are capable of supplying 10,000 lamps of 8 c.p. The total cost of the installation, including buildings, machinery, etc., has been £21,500, which is under the estimate of Prof. Kennedy—set down at £24,000. After the ceremony the station was thrown open to the public, and large numbers of people availed themselves of the opportunity of inspecting the works. Mr. Ruthven Murray and his staff received the visitors.

New Issue by the City of London Company.—The City of London Electric Lighting Company, Limited, as will be seen from our advertisement columns, are inviting subscriptions for additional capital. The present issue is £100,000 5 per cent. debenture stock at the price of £115 per cent. (part of a total issue of £400,000), redeemable by the company at £125 by six months' notice after December 31, 1910. The subscriptions to the debenture stock are payable as follow: £10 on application, £25 on allotment, £40 on April 30, and the remaining £40 on June 30 next. The prospectus states that applications from preference and ordinary shareholders will be preferentially considered. The list of subscriptions opens to-day (Friday), and will close at four o'clock this afternoon.

"Spons's Architects' and Builders' Price-Book." Messrs. E. and F. N. Spon have just published the 1894 edition of this price-book, which is edited by Mr. W. Young, architect. The book contains, besides the information relating to prices, numerous memoranda and tables, and the handy arrangement of the matter in alphabetical sequence, thereby rendering it easy to turn up in a moment any desired formula, has been adhered to as in former editions. The present issue has been revised and enlarged, and among the additional information embodied in it may be mentioned a chapter on electricity and complete specifications and estimates of electric lighting installations carried out in different places. Moreover, extra divisions have been provided on concrete, fireproof floors, and granite.

Personal.—Many of our readers will doubtless be surprised to hear that two gentlemen well known in the electrical field are severing the connections they have held for so long in their respective avocations. We refer to Mr. Edwin J. Houston, professor of Physical Geography and Natural Philosophy in the Central High School of Philadelphia, who has held this chair for the past 26 years and who has just resigned; and Mr. A. E. Kennelly, who during the past six years has been Mr. Edison's right-hand man and chief electrician, and who is about to leave the latter's laboratory. These gentlemen have decided to establish in Philadelphia a firm of electrical experts to be known as Messrs. Houston and Kennelly. It is scarcely necessary to remind our readers that Prof. Houston is president and Mr. Kennelly is one of the vice-presidents of the American Institute of Electrical Engineers. We wish them success in their new undertaking.

"Waste Field" Measurements.—We recently came across an ingenious young electrical engineer who was a good deal employed in equipping and starting up the smaller types of self-contained lighting installations: and the method which he asserted was of great use to him in roughly comparing the qualities of different generators had at least an air of refreshing novelty. He was the proud possessor of a common easily-magnetised silver watch, whose movements were remarkably erratic according to the particular machine alongside which its owner would be working. The latter claimed that the waste field is very nearly proportional to the retarding effect upon his watch: Smith's machines are better designed than Brown's, because they only make it lose half an-hour a day instead of three-quarters. We advised him to develop the idea, and waste the product of his father's fields (he was a farmer's son) by taking out a patent for a pocket Aron meter, or horological magnetometer!

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The Battersea Polytechnic.—The Prince of Wales on Saturday formally opened this polytechnic institute, to which reference has been made on previous occasions. The institute is under the direction of a governing body composed of representatives of the South London Polytechnics Committee, the London County Council, the City Parochial Charities, and the London School Board. The principal ornamental decorations consist of 10 statues, which represent Architecture, Painting, Engraving, Sculpture, Music, Poetry, Chemistry, Electricity, Mathematics, and Engineering. The institute embraces workshops for various trades, physical and chemical laboratories, art-room, photographic-rooms, and numerous classrooms and lecture-halls. Instruction in the following subjects is provided: carpentry, technology (including instruction applicable to plumbing), patternmaking, mechanical and electrical engineering, and the chemical trades; science generally, in accordance with the regulations of the Science and Art Department, etc.

New Form of Induction Balance.—Mr. M. Wien has described a new form of induction balance in a German contemporary. In this form of induction balance the arrangement is very simple, being that of a Wheatstone's bridge, two arms of which are coils having self-induction, and the other two inductionless resistances. A sine current of $\frac{n}{2\pi}$ periods per second flows through these arms, and the telephone which forms the bridge arm is silent when both resistances and self-induction are proportional. Now, if a piece of metal be brought near one of the coils, the balance is disturbed. The coil itself is disturbed, and not the mutual induction of two coils, as in the old form of balance. When balance is restored by suitable adjustment of a secondary coil inside the other inductive coil, the time constant of the metal piece is equal to that of the compensating secondary coil. From this datum the conductance of various metals of similar form may be compared. The paper is an interesting one, and contains an archipelago of experiments surrounded by a sea of mathematics, in which the navigator has some difficulty in keeping his bark afloat.

Loakage from Underground Cables.—Mr. Weir, M.P., is much concerned about high-tension circuits. On Monday, in the House of Commons, he asked the President of the Board of Trade whether his attention had been called to a letter in the newspapers by Mr. James Keith, C.E., stating that outside the precincts of the Houses of Parliament more than ordinary danger from high-tension electric currents had to be faced, seeing the public streets around or near the legislative chambers were intersected in almost every direction by underground high-voltage electric cables, and what could so easily happen under 2,000 volts in Bournemouth might, under certain conditions, and under a higher voltage, perhaps occur more easily in the streets of London; and whether any effective means of dealing with leakage of high-voltage electricity in underground cables had yet been placed at the disposal of the Board of Trade. In reply, Mr. Mundella said that he had seen the letter in question, and that in 1890 the Board of Trade made regulations with regard to high-tension electric currents, in consultation with the Council of the Institution of Electrical Engineers, and these were considered to be quite ample protection.

A Method of Cooling Transformers and Conductors.—In order to carry off the heat generated in transformers working under a heavy load, Prof. Henry A. Rowland, of Johns Hopkins University, has invented a method employing a current of liquid led through the iron in tubes so placed as not to be cut by the lines or magnetic induction, the tubes and iron laminæ alternating with one another. Water, or any other conducting liquid, may thus be employed without interfering with the proper working of the transformer. According to the *Electrical Engineer* of New York, another method employed by Prof. Rowland is to surround the transformer with a vessel containing a volatile liquid, which, by boiling, carries away the heat. The vapour may be recondensed in the upper part of the vessel or carried off through a condensing coil and returned to the vessel in a liquid state. He also provides means for reducing the pressure in the vessel, in order that the liquid may boil at a low temperature. To cool conductors carrying heavy currents, Prof. Rowland suggests making them hollow and passing a current of cooling liquid, such as water, through them from end to end, the liquid issuing in the form of spray to break the continuity of the stream and thus insulate it from the vessel into which it flows.

Mason College, Birmingham.—"Founder's Day" of this college was celebrated a few evenings ago by a dinner, under the presidency of Lord Kelvin. In proposing "The College," his lordship said engineering, mechanical, civil, and electric, formed one of the departments of Mason College. Under the able Prof. Robert Smith admirable work had been done. All admired the great energy, the great knowledge, and the great skill and capacity for acting with which that department was worked. But it wanted strengthening obviously. It wanted strengthening in the way of addition to its *personnel*. They could scarcely strengthen the *personnel* itself, but they wanted one more professor, and certainly additional lecturers, and the means and appliances for an engineering laboratory. The modern estimate for an engineering laboratory was £25,000. Surely £25,000 could be found for an engineering laboratory in the Midlands University. The chemistry department had good laboratories. When he turned to the physical laboratory he found there was still much to be done. They wanted a strong physical laboratory. He thought the citizens of Birmingham might take more advantage of the college than they did. Instead of there being the present inconsiderable number of students—600, or 700, or 800—there ought to be at least 2,000 in such a college.

An Electrical Parcel Van.—Following up the experiments made by Mr. Radcliffe Ward with electric vehicles for operation on our streets, another attempt is about to be made to render this method of traction popular and successful. This time it is Messrs. E. J. Clubbe and Co., of 16, Elm-street, Gray's-inn-road, W.C., who are interested in the matter, and who will shortly place on the streets an electrical parcels van fitted with Fitzgerald's improved secondary batteries. By a careful arrangement the working parts of the van are reduced to a minimum, leaving the whole of the interior of the body free for passengers or goods. The accumulators supplying the motive power are suspended in a special carrier beneath the body of the van, and a recharged set may be substituted in two minutes. The van is lighted by electricity, and is controlled by a single switch giving six degrees of speed. The company estimates that the cost of working a van by electricity equal to a two-horse vehicle, including charging, maintenance, etc., will be 2d. per mile run. The car will run a distance of about 30 miles before recharging of the batteries becomes necessary. The body of the vehicle was built by Messrs. Liversedge and Sons, the mechanical parts by Messrs. Easton and Anderson, Limited, the motors were supplied by Messrs. J. G. Statter and Co., and the vehicle was designed by Mr. Walter C. Bersey.

The Pacific Cable Question.—The Premier of Queensland (Sir Thomas M'Ilwraith) arrived in London on Wednesday. He will during his stay on this side attend

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to the inter-colonial cable and mail route questions. Interviewed by a correspondent, Sir Thomas stated he had seen all the Canadian Ministers on the subject of the cable, and had also interviewed leading Americans. He said nothing but a British cable was contemplated, which, if established, would prevent an extension of the French cable from New Caledonia to Vancouver, as it was not intended to lay two cables. In this connection, the *Pall Mall Gazette* says: "Now that it is fixed that there is to be an intercolonial conference at Ottawa next June, one can only hope for one thing. That is, that the Imperial Government will show some interest, even a slight interest, in a meeting called in response to the unquestionable enthusiasm of the colonials. Canada, Australia, New Zealand, (and Hawaii) are to be represented. The main points for discussion are the new Pacific cable and the proposed Pacific Steamship Company which is to run (under subsidy) from Vancouver to Australia. Both will be obvious advantages to the Empire as the keen eyes of Younger England see plainly enough. It is ridiculous that a French monopoly should hold the only telegraphic bridge between Canada and Australia, and a very inefficient one. The sooner we bestir ourselves the better for our colonies and for us."

Sewage Purification at Worthing.—The experiments in electrical sanitation, to which we have referred in recent issues, commenced at Worthing on Monday. M. Hermite attended to explain to the mayor and Corporation the essential parts of his system. Arrangements have been for some weeks past in progress, the scene of the experiments being a row of small cottages in West-street. The experimental plant is erected in a contractor's yard near at hand, where a dynamo and engine are situated. To the mayor and Corporation, and to a number of local medical men, the system was explained by the inventor, and by Mr. Cooper, an electrical engineer who had been associated with him in his experiments in France. The necessary bacteriological and chemical analyses, which are to determine the practical value of the invention, are being undertaken by Sir Henry Roscoe and Dr. Armand Ruffer, the president and secretary respectively of the British Institute of Preventive Medicine. After an inspection of the operations, the party went to the Council-chamber, where a number of questions was put to the inventor. M. Hermite said as to the cost, it was found that the disinfecting solution could be brought to the houses for about one shilling per head per annum. This would give about nine gallons per head, which would suffice not only for flushing purposes, but also for washing floors, and for use in sick-chambers. By the adoption of the system, he believed it to be possible to do away with diseases of many sorts, and to make a perfectly healthy town; but to do that the electrolysed water must be distributed in every house. It might be supplied to consumers in the same way as gas or electricity, and thus become a source of municipal income. It was stated by the mayor that the representatives of a large number of municipal bodies in the kingdom were anxious to witness the system in operation, and it was understood that they would be communicated with, so that they might inspect the system in operation.

Are Horses "Peculiarly Susceptible to Electric Shock"?—This question has arisen in connection with the recent accident at Bournemouth. "The answer," the *Lancet* observes, "will depend upon the sense in which the word 'susceptible' is used. Used as it is here, it would seem to imply that an electric current on entering the body meets with some anatomical peculiarity or physiological 'susceptibility' that makes the horse more vulnerable than other animals to the action of such a current. In this sense it is difficult to see good grounds for the statement. If, however, it is intended to say that the conditions under which horses usually work facilitate the access of electric currents to the body the statement has doubtless good foundation. The hoof, and more particularly its crust and sole, is a good insulator, but, being shod, there is not only presented to the ground a large metallic contact, but this contact is in connection with metallic conductors in the shape of nails, which pierce the strongest part of its insulation and afford an easy electrical path into the body. The great superincumbent weight of the animal is another element in improving the contact with 'earth.' Further, it may often happen that in passing over wet ground the external surface of the hoof and the hair of the fetlock, especially in the case of untrimmed horses, may become sufficiently wet to form a good surface conductor, and so carry a current directly from the earth to the upper part of the body, thereby eliminating the safety afforded by the natural 'resistance' of the hoof. It is also to be remembered that a horse, covering more ground than a man, will be in contact with points of ground further apart, and thereby risk is increased. These considerations do not, of course, touch the question of accidents to horses during thunderstorms. In these cases the animal is often killed by what is known as 'return shock' (the sudden discharge of an insulated conductor), and here the insulation afforded by the hoof, so far from being protective, becomes an additional element of danger."

Experiments on Electro-Dynamic Screening and Electric Shadows.—A paper has been published in *Wiedemann's Annalen* by Messrs. H. Ebert and E. Wiedemann dealing with this subject. The authors have set themselves to thoroughly investigate the question already examined by Hertz and Stefan, and used for the purpose the parallel wires described by Lecher, connected by a conductor at one end, and at the other joined up to two condenser plates standing parallel to one another. When an exhausted and electrodeless tube is brought near the condenser, it is illuminated so long as the primary spark is passing, and consequently its extinction is a mark of screening from electrical oscillations. In the experiments described in the paper, the vacuum tube and the screening body were placed with their length parallel to the axis of the condenser, and away from the parallel wires; and the order in which they were arranged was either—condenser, screen, tube, or condenser, tube, screen—according as the experiments were on screening in front or behind. If the screen was not a wire or tube, but a metal plate, then the question of direction of its plane was also a factor to be noted. It was found that screens of metal, or of any substance which screens behind itself, shield also in front and alongside themselves. The thinnest sheets of metal, even when transparent (like gold leaf), are screens; tubes also filled with a solution of electrolyte, even when very weak; but insulators, such as glass and mica, do not screen. The dielectric in which the screening body is placed has not observable influence on the result. If the screen is to work at a distance of 1cm. from the tube, it must be at least one-third to one-half of the length of the column of light, and when moved further away must be longer still to entirely quench the light. Tubes filled with rarefied gases do not screen in themselves, but become shields if made to glow by electric oscillation. The authors sum up as follows: Round conductors there is produced under the influence of electrical oscillation a screened space, both in front, behind, and alongside; and excitable bodies placed in this space are not excited so long as their capacity for excitation is not too great in comparison with the screening

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action at that point; and luminous gases take part in this property of conductors.

The Cultivation of the Inventive Faculty.—A pamphlet on this subject has been written by Mr. B. H. Thwaite, A.M.I.C.E., F.C.S., etc., who concludes that the cultivation of the inventive faculty in this country would be greatly assisted by the adoption of the following suggested list of reforms in our laws relating to patents for inventions: "(1) The reduction of the patent charges to the level of those of the United States of America, and to cover a period of 17 years instead of 14 as at present. The payments to be £2 on application and £5. 10s. on completion. (2) The provision of officially approved and Government paid agents in suitable centres of population to guide inventors in the preparation of their patent documents before lodgment. A nominal sum, depending upon the character of the invention, number of drawings, and length of specification, to be charged. Present chartered patent agents might be appointed to the official position. (3) A commission of experts shall, whenever possible, examine working inventions in actual, industrial, or other use. If such reasons are of a financial character, and if the commission of experts decide favourably, conditional financial advances are to be made to enable the invention to be worked. (4) The examination of the claims of the inventor to be made by officially appointed, highly technical, scientific and other experts. (5) Patent case disputes to be decided by a tribunal composed of technical or other experts, no legal counsel to be permitted on either side. List of interrogations to be drawn up by the expert tribunal. (6) If the inventor is aggrieved by an infringement, and he shall give satisfactory proof of his financial inability to obtain satisfaction, the Government shall be permitted to provide the necessary aid to enable the inventor to obtain justice. (7) In the event of the non-working of the invention after a specific period—to be determined—the inventor to show satisfactory reasons for such inaction. (8) Orders of merit to be granted every year for the best invention relating to every important industry or for the creation of a useful new one. (9) The Government shall issue a list of improvements required in different branches of industry, to the solution of which the faculty of invention might be usefully applied."

Hotel-Lighting.—Although some little surprise might naturally be felt at the installation of self-contained electric lighting plants within areas already supplied by street mains, it is hardly to be wondered at that such should still exist in places where they have worked efficiently and economically for some years. The authorised price per unit of supply from a public electric light company in nearly all cases proves much higher than the cost incurred by operating a plant of large size; and the owners of self-contained installations are not therefore likely to throw out their generating plant from a public-spirited wish to help in eventually reducing the price of supply from street mains to what it now costs them. Even in the centre of the Metropolis there are, therefore, many complete installations, some of which have been at work for years, and which will probably continue to be operated until the need for extensive repairs or additions make it preferable to take supply from outside. Amongst such may be mentioned the plant engaged in lighting the Cannon-street Hotel and offices. Here, in a small yard at the side of the railway station, is a very compact little building which contains a loco.-type steam-boiler by Hornsby—of 90 h.p.—with Berryman feed-water heater, Holden and Brooke's automatic injector, as well as a Worthington pump, supplying steam to a couple of Willans compound engines, one of 60 h.p. and the other of 38 h.p. These are coupled direct to two Castle dynamos by Holmes and Co.—one shunt wound, giving 300 amperes at 115 volts, the other compounded, with an output of 180 amperes at the same pressure. The latter machine is provided with a switch for throwing out of circuit the series winding when it is necessary at full load to run both dynamos in parallel. Six main circuits are taken into the hotel and station buildings, with sub-main boards and distribution boards. The Great Hall—measuring 80ft. by 40ft. by 40ft. high—is wired in ring fashion, with feeders brought in at six equidistant points, forming practically six separate sections, each governed by a switch. The current from the main switchboard in the generating station passes through an Aron meter capable of registering up to 800 amperes. The credit of designing and carrying out the entire installation—generating plant, distribution, wiring, etc.—is due to Mr. W. Durtnall, A.I.E.E., who acts as electrical engineer to the hotel proprietors.

The Tesla High-Potential Conductor.—In order to prevent loss by dissipation or interference by induction on line conductors carrying high-potential alternating currents, they have in some instances, such as at Deptford, London, been insulated and enclosed in a continuous conducting sheathing, which is connected with the ground by a good conducting path. The *Electrical Engineer* of New York states that, while conducing to the safety of the system, Mr. Tesla has found that the use of a conducting sheath or screen around the line conductors and well grounded, or even brought into proximity to external conductors or large bodies, is attended by an actual, and generally a serious, loss of energy, which is the greater the greater the number of alternations and the higher the potential. He therefore maintains the sheath entirely isolated or connected directly or inductively to the ground, through a path which will practically prevent the passage of currents over it. He has also found that when a continuous isolated sheath or screen is employed, there is greater liability to loss of energy by inductive action; for unless the sheath or screen be considerably shorter than the current waves passing in the conductor, E.M.F.'s will be set up between different points in the sheath, which will result in the passage between such points of induced currents. Mr. Tesla therefore divides up the sheath or screen into short lengths very much shorter than the wave lengths of the current used, so that the grounding of any one of such lengths or the approach thereto of a large body will result in an inappreciable loss, or at most a small local draining of the energy, while the tendency of currents to flow between different points in the sheath is effectually overcome. The function of the sheath as a static screen for preventing the dissipation of the electric energy, however, requires for its complete effectiveness an uninterrupted conducting partition or screen around the conductor. In the case of a sectional screen this is obtained by causing the ends of the insulated divisions or sections to overlap, and interposing insulating material between the overlapping portions. For transmitting currents of very high potential and very high frequency, Mr. Tesla provides between the sheath and the ground a path of very high ohmic resistance, or one containing a self-induction coil properly determined with respect to the existing conditions so that it will effect the desired result, or a condenser of very small capacity. In such cases the sheathing or screen for practical purposes may be regarded as isolated from the ground, since by the character of the connection employed no appreciable loss results from the passage of current from the sheath to the ground.

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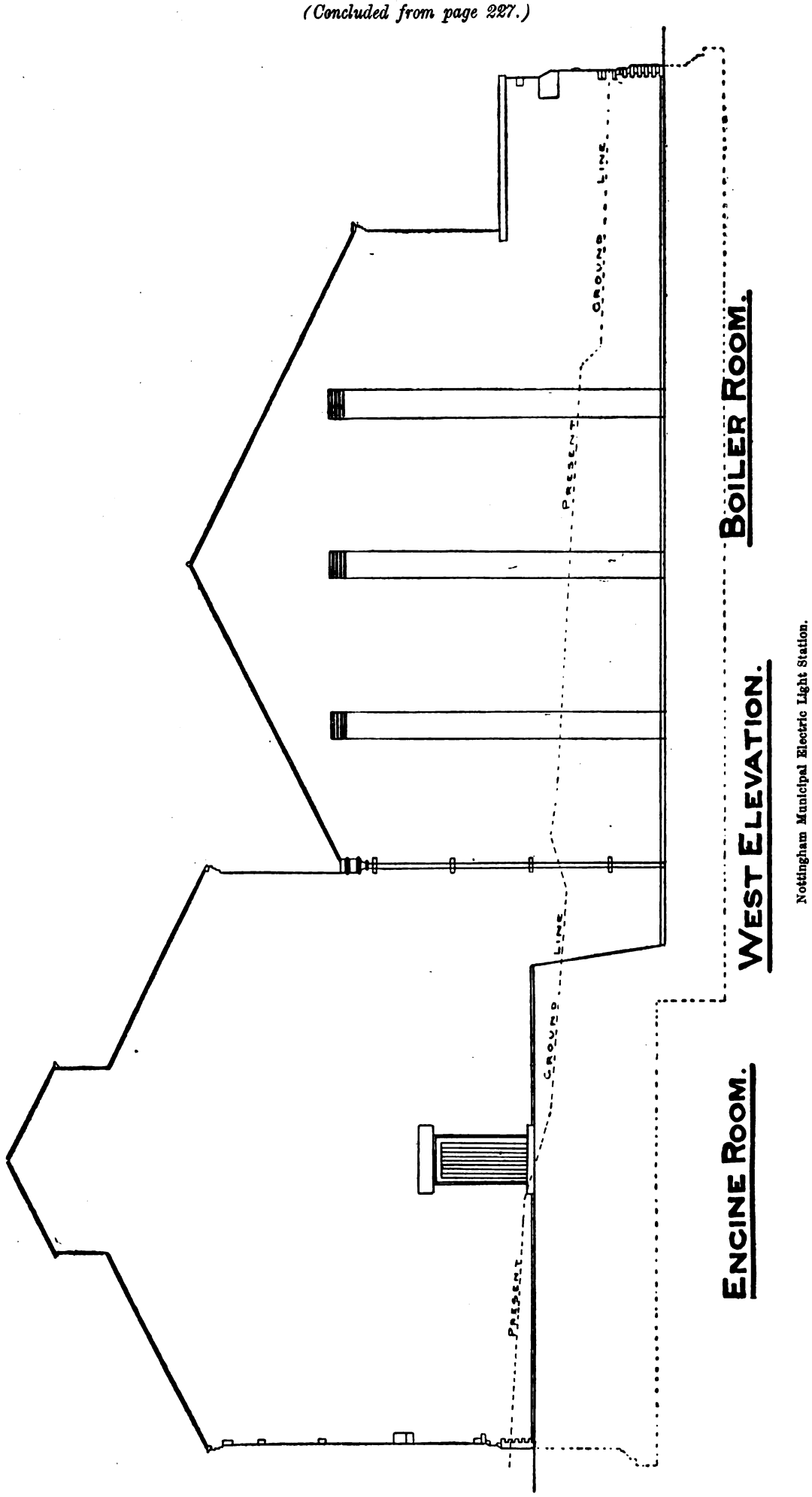
THE NOTTINGHAM MUNICIPAL ELECTRICITY WORKS.

(Concluded from page 227.)



Referring to the plan showing the general arrangement of steam-pipes, A represents branches of 3in. bore, and B branches of 4in. bore; C shows patent isolating valves, D blank flanges, E 1in. branches, 6in. long, on the top of

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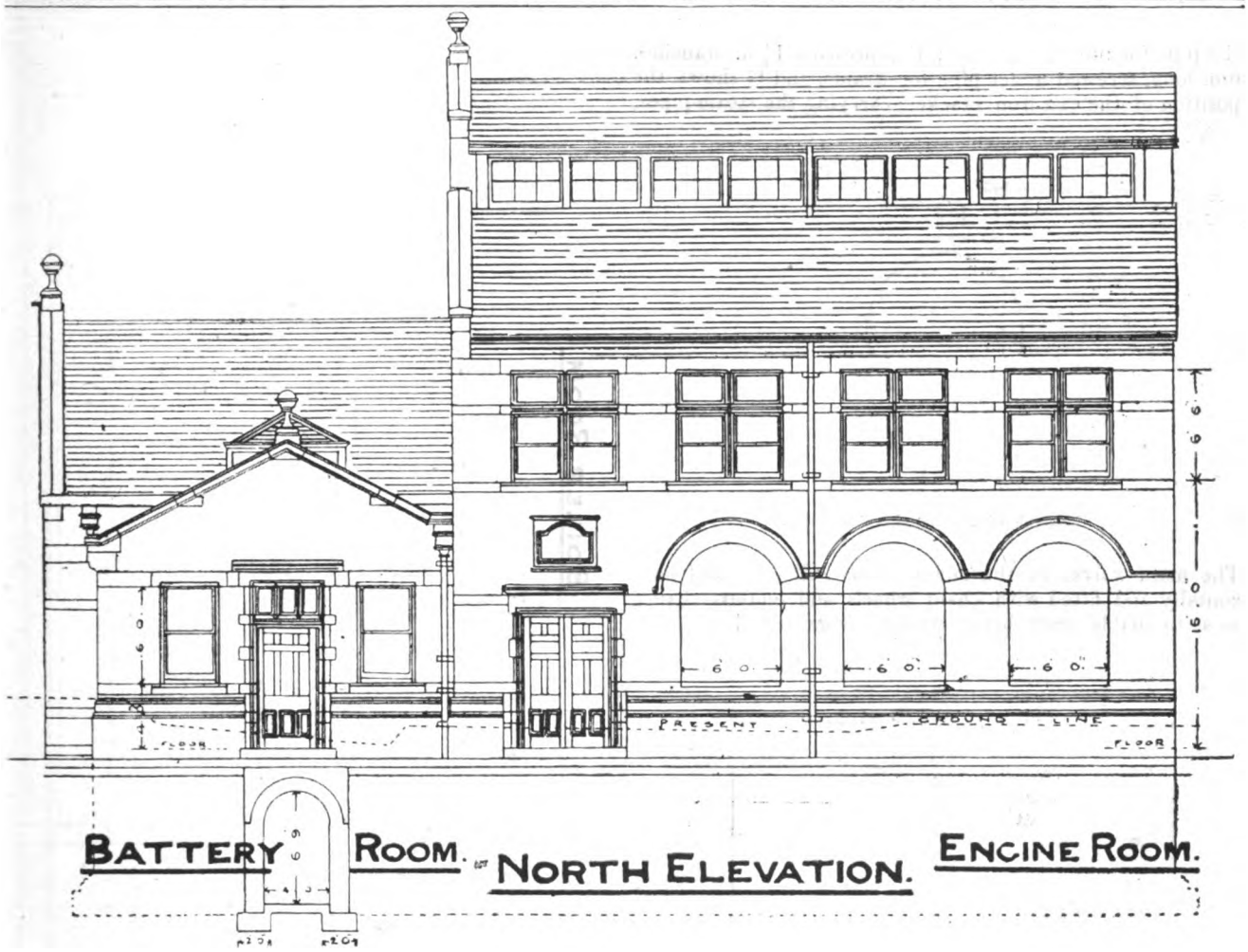

Nottingham Municipal Electric Light Station.

SECTION. H.H.

Nottingham Municipal Electric Light Station—Engine and Battery Room.

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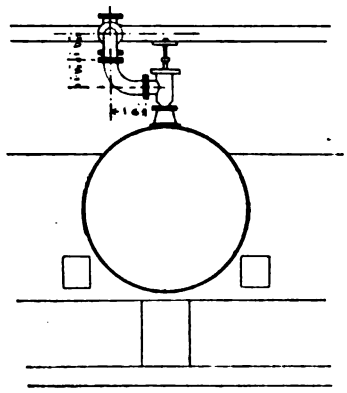
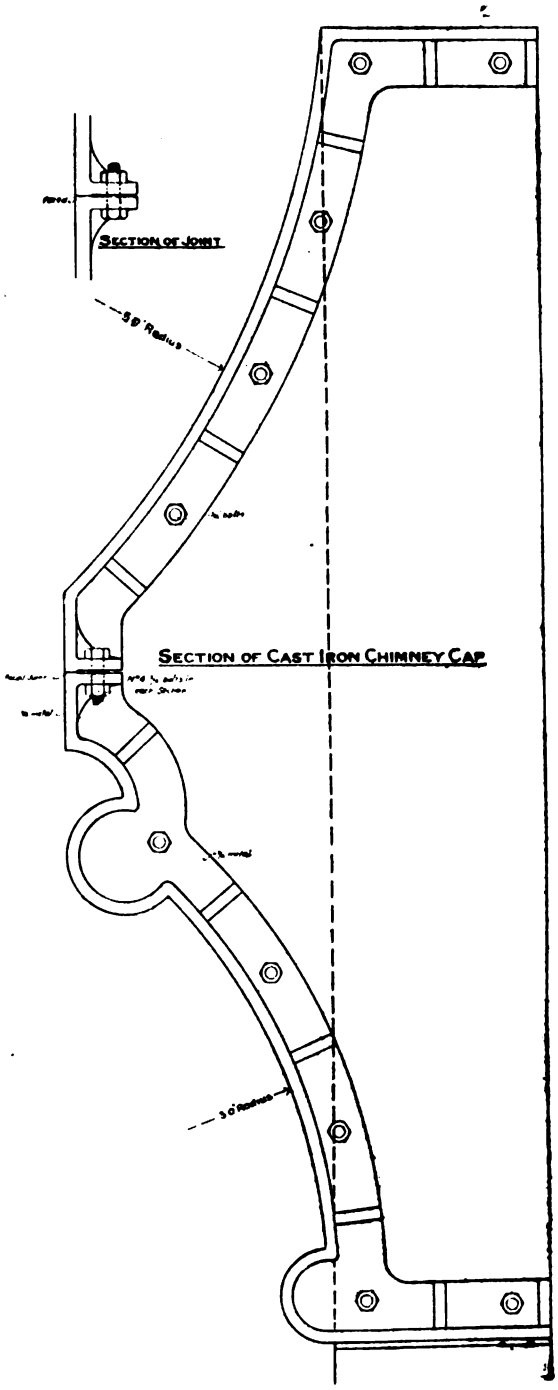
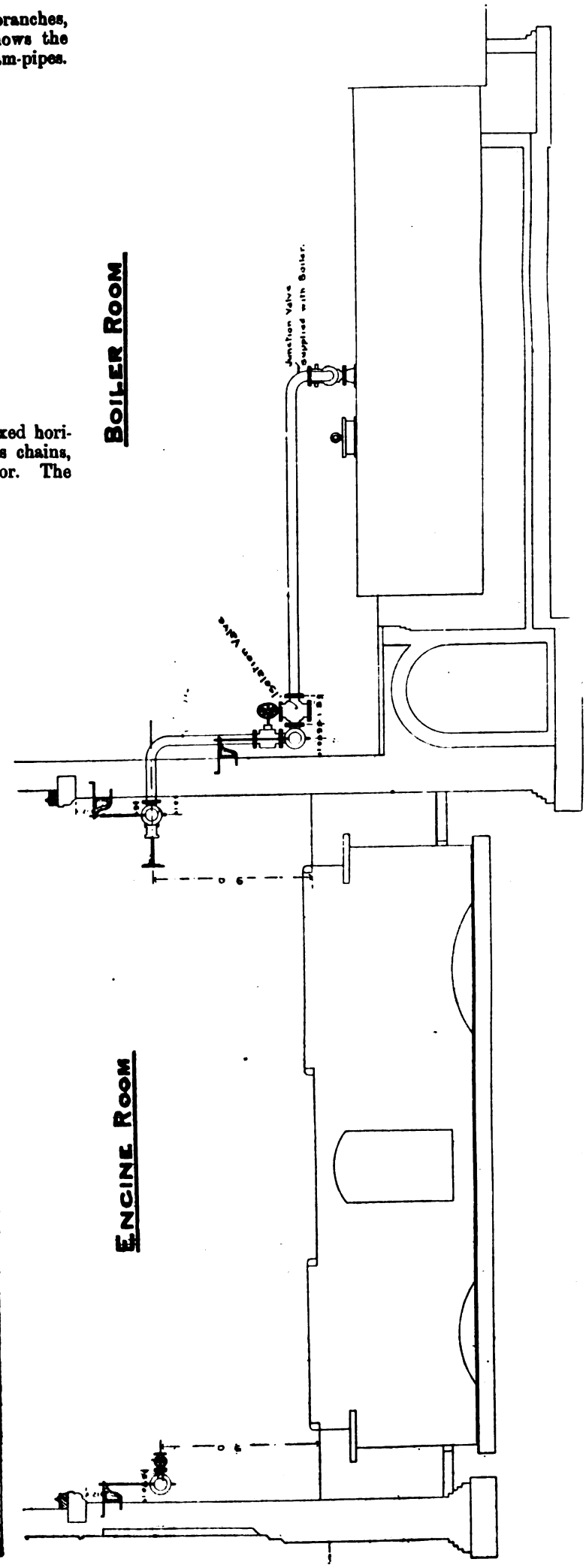
the pipe for pressure gauges; F represents 1¼in. branches, 6in. long, screwed under pipe for drains, and G shows the position of the cast-iron brackets carrying the steam-pipes.



Boiler, showing Steam-pipe Connection.

The main valves in the engine-room will be fixed horizontally and fitted with chain wheels and endless chains, so as to enable their being worked from the floor. The





Cross-Section, showing Arrangement of Steam-piping

Nottingham Electric Light Station.

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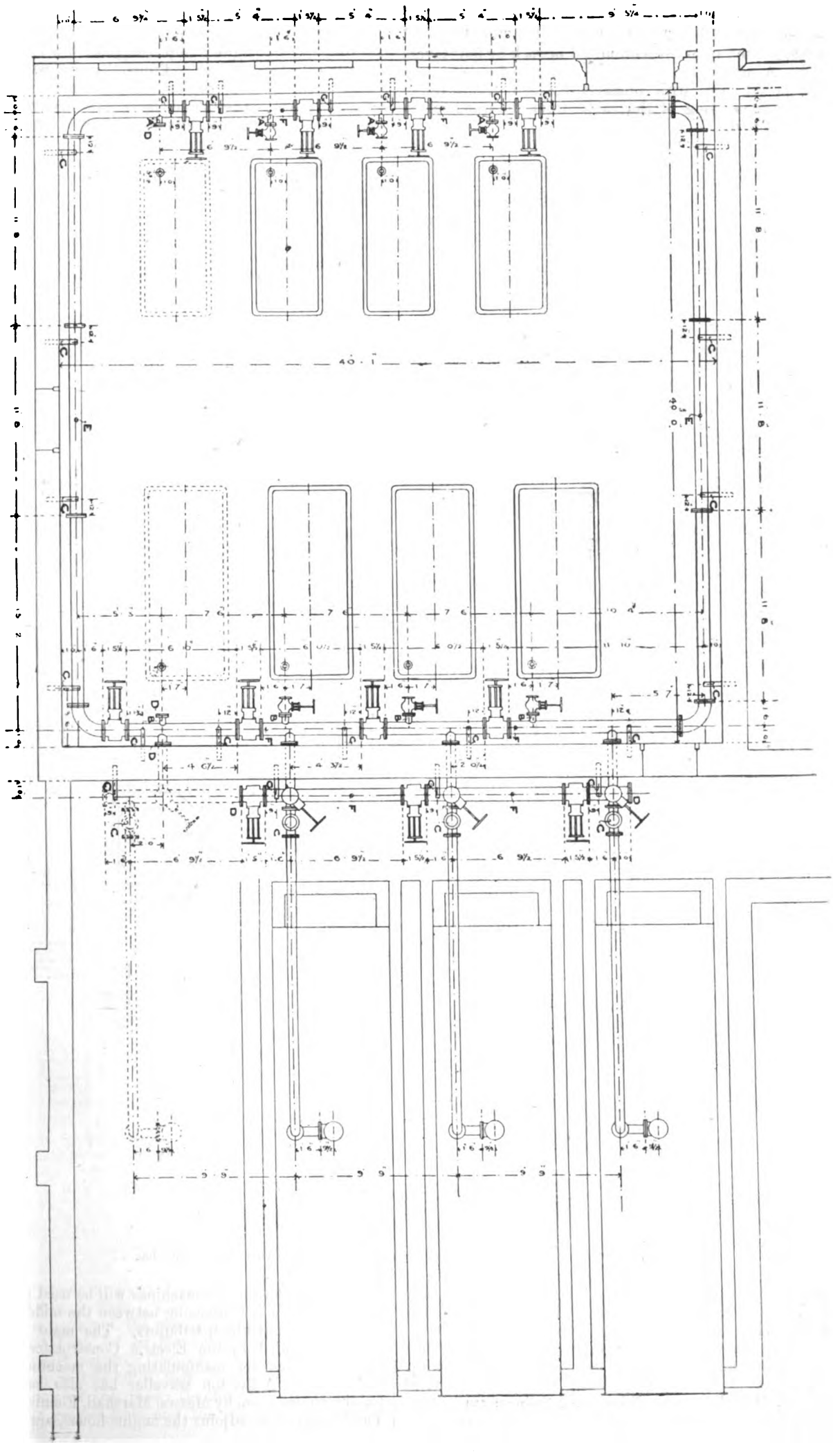

Nottingham Electric Light Station—Plan showing General Arrangement of Steam-piping.

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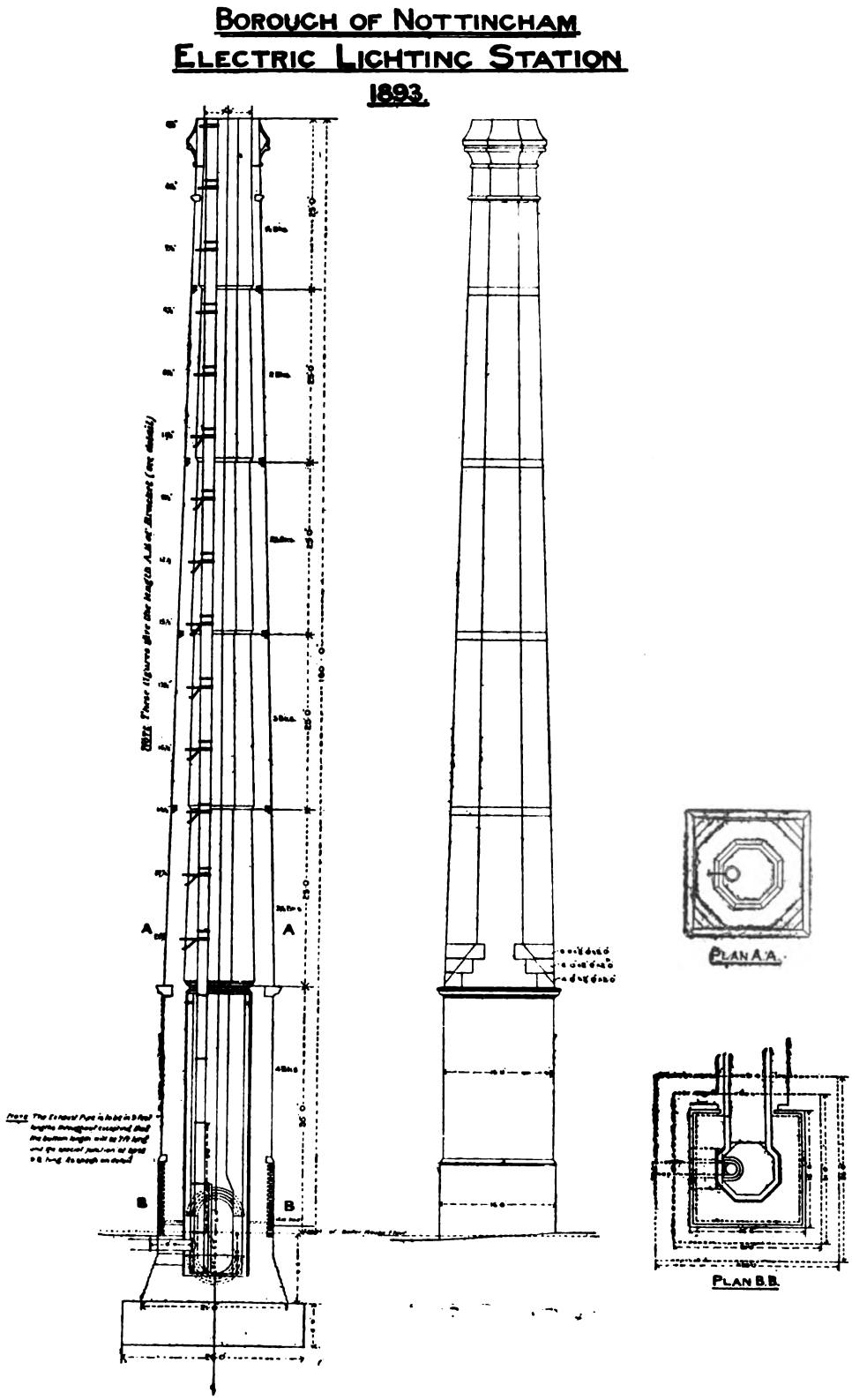
engine-house is 40ft. by 40ft. and 24ft. high to springing of roof. The foundation for the engines is composed of one concrete block 34ft. by 30ft. by 9ft. 6in. deep, and this is separated from the bottom bed of rock by four layers of felt. A subway 4ft. by 6ft. 6in. has been formed in the centre of the bed, with brackets built in the sides to facilitate the carrying of the cables from the dynamos to the switchboard.

There will be six machines of the following output: three dynamos, each of 370 amperes at 220 volts; three dynamos, each of 330 amperes at 145 volts. They will be mounted on combination frames and coupled direct to the fly-wheels of the engines. Copper pipes will be used for connecting the engines to the main steam and exhaust pipes. The three large dynamos will be used for running on to the outside feeders of the three-wire



Elevation and Section of Chimney Shaft, showing Exhaust-steam Pipe carried to the top.

The contract for the engines and dynamos has been placed with Messrs. Siemens Bros. and Co., Limited. The engines will be of the Willans central-valve compound type, single acting, having all brasses in constant thrust. There will be three engines of 80 h.p. each and three of 134 h.p. each, and space on the foundation for an additional one of each size. The dynamos will be of the Siemens type, shunt wound, with single magnetic circuits and bar armatures. system, and the smaller machines will be used for charging the batteries or for balancing between the middle cable and either of the outside distributors. The main switchboard is being supplied by the Electric Construction Company, and is arranged for manipulating the machines, batteries, and feeders. A five-ton traveller has also been supplied for the engine-room by Messrs. Marshall, Fleming, and Jack. The battery-room adjoins the engine-house, and is 40ft. by

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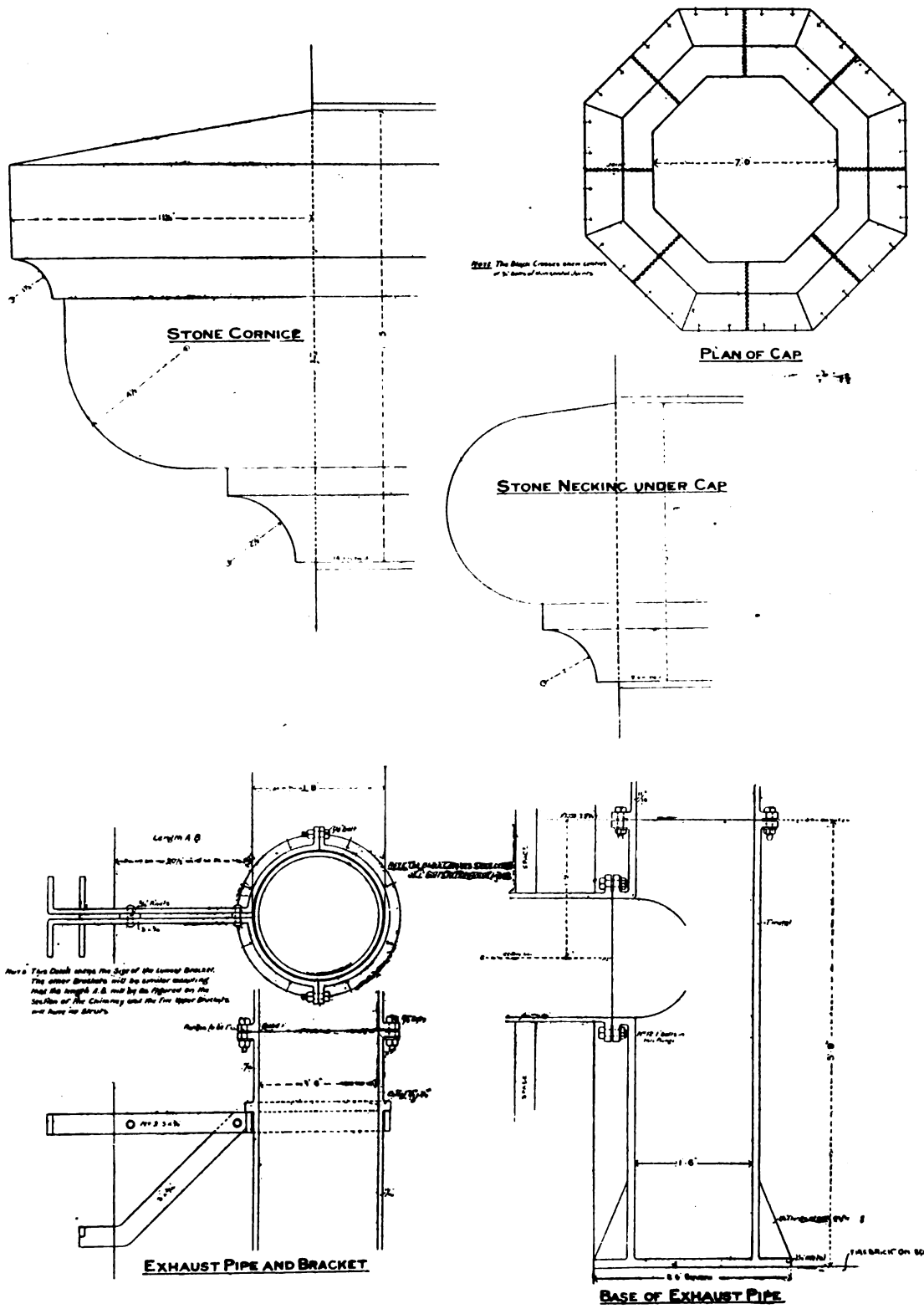
20ft., and the floor will be paved with Val de Travers asphalte. A battery of 112 K-type cells is being supplied by the Electrical Power Storage Company, Limited, and is to be capable of giving 150 amperes at 212 volts for seven hours, or 500 amperes at 210 volts for one hour.

From the main switchboard brick subways for cables have been laid to each street upon which the station abuts, and from thence along and through the 18 streets named in the order conduits have been laid on the Callender-Webber draw-in system. The contract for this work, including the laying of the conduits and the running of the cables, has been let to Messrs. Callender's Bitumen, Telegraph, and Waterproof Company.

The chimney will be 160ft. high above ground-level, and 16ft. 6in. square at the base; the flue will be 7ft. across the octagon at ground-level, and the main exhaust steam pipe, 18in. diameter, will be carried inside the chimney to the top.

The buildings are being constructed of brick with Derbyshire stone dressings, glazed bricks being used for facing the inside walls of engine and boiler house and battery-room. The buildings are so arranged that when the demand for light increases, the engine and boiler house may be extended on the west side thereof. The contract for the buildings and chimney was let to Mr. Messom, of Nottingham, and the work is now being very rapidly pushed forward. It is unfortunate, however, that there has been a delay of over three months in the erection of the buildings, as in consequence of the dispute in the coal trade it was impossible to obtain a supply of glazed bricks. It is expected, however, that the station will be completed by about next July.



Nottingham Electric Light Station—Plan of Cap, and Illustrations of Stone Cornice, etc.

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The buildings, chimney, etc., have been designed by and are being carried out under the direction of the borough engineer, Mr. Arthur Brown, M.I.C.E., and the whole of the electrical engineering work is being carried out by Mr. Herbert Talbot, M.I.E.E., electrical engineer to the Corporation.

ELECTRIC LIGHT AND POWER.

BY ARTHUR F. GUY, ASSOC.MEM.INST. ELECTRICAL ENGINEERS.

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(Continued from page 166.)

TESTING CIRCUITS.

When the leakage current exceeds the fixed amount allowed, or when the insulation resistance falls below the fixed standard, whatever this amount or standard may be, then the circuit must be considered as faulty or defective, and should at once be tested so as to locate and remove the fault. Sometimes the falling away of the insulation resistance cannot be traced to any particular point. In that case, it is most probably a general deterioration of insulation throughout the circuit, and nothing can be done except take down what appears to be the worst section, and replace with new mains. Faults may be divided into two classes—(I.) partial earths, (II.) dead earths.

A partial earth signifies some weak spot in the insulation covering where the covering is partially worn away, due to corrosive action, abrasion, or mechanical damage of any kind. A partial earth may also be caused by "wet rot." This condition of the insulation is usually brought about by damp state of the atmosphere or walls, or dripping water, action of steam, etc. The insulation then becomes softened and "soddened," and when the two cables get touching, or close together, the leakage current becomes abnormally great; and with wet casing, electric sparks will flash intermittently across the path. This leakage and minute "arcing" will eventually overheat the insulation and casing, which will probably burst into flame.

A dead earth is obtained when there is actual metallic connection between either of the mains and "earth"; by "earth" is signified any system of water or gas pipes, or any such unconfined conducting or semi-conducting medium that would allow the current to leak away; it also means the actual soil. Of course, when there is a dead earth on both mains, a short-circuit is produced, for the current will enter earth by one main and leave by the other.

A rough test for earths is shown in Diagram I. of Fig. 42. G and B signify a linesman's galvanometer and battery, one pole or wire of which is put to earth, and the other is joined on to one of the mains, which is disconnected from the other main by the removal of all lamps; then, if there should happen to be an earth on the main to which the galvanometer is connected, the needle will show a greater or less deflection, because the circuit will be completed. In a similar way, an earth or fault can be detected in the other main by joining up the galvanometer to that main. This simple test does not give any quantitative information respecting the fault: it only shows in a rough way that a fault is extant.

To obtain a quantitative test, or measure the insulation resistance of the circuit, some such testing set like the "Silvertown" one must be used. This set is, perhaps, the best there is for rough practical use, such as in central-station work, and it is particularly handy for this sort of work. It is described and illustrated in several books on electric appliances, and those who do not know it can find it in Jamieson and Munro's pocket-book. The method of using this set is as follows: Insert the two battery wires into the two terminal holes marked "insulation," and having first adjusted the needle of the galvanometer to zero by means of the controlling magnet, then plug up the hole marked "10,000 ohms," and observe what deflection is given and what shunt is used. The best combination of battery power and shunts to be used must be guided by the probable value of the insulation resistance, because to obtain the best results the deflection obtained from the insulation resistance must be made to coincide as near as possible with that obtained from the 10,000 ohms. In addition, it is always best to obtain a deflection as near as possible to 45deg. When this operation has been done, one of the mains of the circuit about to be tested is connected up to the screw terminal marked "insulation," placed on the left-hand side of the galvanometer. A wire is then attached to the right-hand screw terminal, marked "earth," and its other end is fixed on to a gas or water pipe, to make a good earth. To get a bright and clean contact, always scrape away the surface or skin of the pipe, as the test depends on having a good "earth." All that now remains to be done is to connect up the battery wires as before and plug up the hole marked "insulation," which is next to the 10,000-ohm hole. Note the new deflection and the shunt, if any shunt be used.

There are thus three variables in use: first, the number of cells; second, the shunt used; third, the value of the deflections.

With cells and shunt constant, $R_i \propto$ inversely as deflection.
With cells and deflection ,, $R_i \propto$,, ,, shunt.
With shunt and deflection ,, $R_i \propto$ directly as cells.

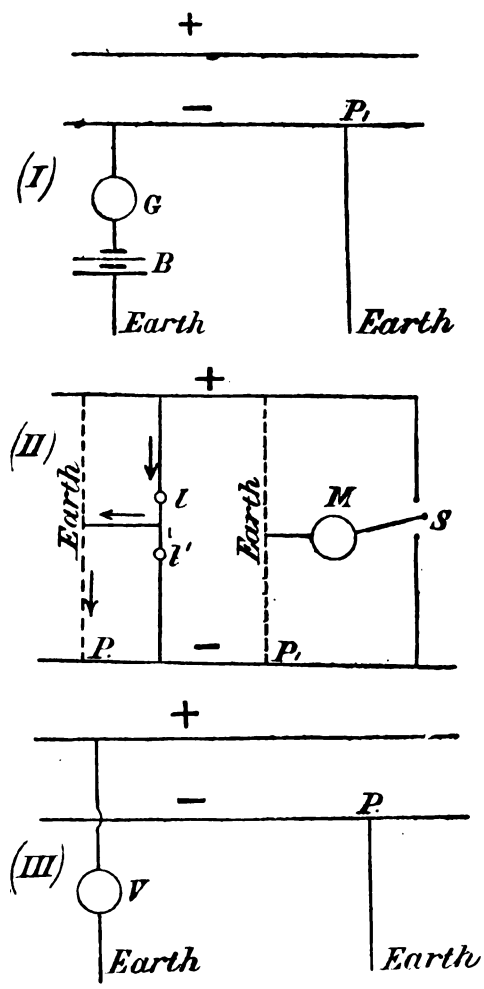

FIG. 42.

The above statements can easily be reasoned out, R_i signifying insulation resistance as compared to the standard resistance of 10,000 ohms. These can be expressed in the following formula:

$$R_i = \frac{D_1}{D_2} \times \frac{S_1}{S_2} \times \frac{N_2}{N_1} \times 10{,}000,$$

where D_1, S_1, and N_1, refer to the deflection, shunt, and number of cells when using the 10,000-ohm plug, and D_2, S_2, and N_2, the same when using the insulation-resistance plug.

When using the 10,000 ohms, it is usual to obtain what is termed a constant. This is obtained by multiplying the 10,000 ohms by the deflection, then by the value of the shunt, and then dividing by the number of cells used. Putting K for constant, this gives us

$$K = \frac{10{,}000 \times S_1 \times D_1}{N_1}.$$

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When this constant is found, the formula for the insulation resistance becomes

$$R_i = \frac{K N_2}{D_2 S_2}.$$

The writer appends the results he obtained when using this testing set a short time ago, the deflections being for various numbers of cells and various shunts. With the 10,000 ohms in circuit these deflections vary slightly with the condition of the cells, etc., so they must not be taken as anything fixed. The last column gives the constant, K, calculated out. The two shunt plugs are marked $\frac{1}{9}$ and $\frac{1}{99}$; this signifies that when the $\frac{1}{9}$ plug is inserted, the multiplying power of the shunt is 10—that is to say, that only one-tenth of the total current passes through the galvanometer, the remaining nine-tenths passing by. Similarly, when the $\frac{1}{99}$ plug is in, the multiplying power of the shunt is 100.

TABULATION 33.

Deflection $= D_1$.	Shunt $= S_1$.	Cells $= N_1$.	Constant $= K = \frac{D_1 \times S_1 \times 10{,}000}{N_1}$.
42	10	10	420,000
4	100	10	400,000
Too high	10	20	—
8	100	20	400,000
Too high	10	30	—
11	100	30	366,666
Too high	10	40	—
15	100	40	375,000
Too high	10	50	—
18	100	50	360,000
Too high	10	60	—
23	100	60	383,333

The average value for K is 386,000.

These constants ought, of course, to all come out the same value. Their variation, however, is accounted for by different degrees of sensitiveness for various deflections, inequalities of cells, etc.

Diagram II. of Fig. 42 illustrates a very good way of obtaining a continual indication respecting the state of the insulation resistance. Two lamps of 16 c.p., l and l_1, are connected in series across the mains, and the wire connecting them in series is led to earth. The brilliancy of the lamps indicate the state of the insulation resistance of the circuit. In central stations the lamps can be connected to the two omnibus bars where a low-pressure parallel system is used. Suppose some part of the – conductor makes an earth somewhere, as shown at P, then a flow of current will take place from the + conductor through lamp l to earth, and thence to the – conductor, as shown by the arrows; consequently, the lamp will glow more or less brilliantly according to the quantity of current flowing through it, and this will depend upon the resistance there is between the earth and the – conductor. The same thing occurs when the + conductor has an earth on it; then, however, the lamp l_1 will glow instead of the lamp l, so that the brilliancy of that lamp connected to *one* conductor will indicate the state of the insulation of the *other* conductor.

When both lamps glow equally, then the insulation resistance of each conductor is equal. The lamp, however, only gives a rough test, and in order to obtain some measurement of the leakage current, it is necessary to employ a low-reading ammeter. This method is shown in Diagram II. also; for in place of the two lamps the ammeter, M, is placed, having a switch, S, so that either the + or the – side of the circuit can be connected up. Let the ammeter be joined on to the + side, and suppose it shows a current of ·8 of an ampere. This means an earth on the – side, shown by dotted lines between P_1 and earth, which thus allows a small current to flow from the + to the – side; and, since it is assumed that the resistance to this leakage current is between earth and the – side, hence it measures the insulation resistance of the – side; the resistance of the ammeter being extremely small, it may be neglected. Applying Ohm's law, this insulation resistance is obtained by dividing the pressure of the circuit by the leakage current. Suppose the circuit pressure is 110 volts, the leakage to earth on the – side is ·8 of an ampere, then the insulation resistance of the – side will be $110 \div \cdot 8 = 137$ ohms. For this test very low-reading ammeters are required, ranging from 0 to, say, six or seven amperes, with readings of one-tenth of an ampere, and these are not met with in central stations. The following test, however, is one that can always be made. It consists in simply supplanting the ammeter by a voltmeter, the only thing that is necessary to be known being the resistance of the voltmeter.

Diagram III. illustrates the connections. If there is an earth on the – side there is a deflection of the voltmeter when joined up to the + side, the result of a small current flowing from the + side through the voltmeter, and then along the dotted path between earth and the – side. The total resistance between + and – side consists of the resistance of the voltmeter and the resistance between earth and the – side, this latter forming the insulation resistance of the – side.

Let r = voltmeter resistance;
R_i = insulation resistance;
E = pressure of the circuit in volts;
D_1 = deflection of voltmeter across mains;
D_2 = deflection of voltmeter across mains when earthed.

The deflection obtained will be inversely proportional to the total resistance.

Hence $$\frac{D_1}{D_2} = \frac{R_i + r}{r};$$

but $D_1 = E$ because it indicates numerically the voltage of the circuit. Therefore, supplanting D_1 by E, we have

$$\frac{E}{D_2} = \frac{R_i + r}{r}; \quad \therefore R_i = \frac{E r}{D_2} - r.$$

Taking a practical case, let the pressure of the circuit be, say, 110 volts, the resistance of the voltmeter 2,000 ohms, and suppose we obtain a deflection of 12deg. when connected between the + omnibus bar and earth; then

$$R_i = \frac{110 + 2{,}000}{12} - 2{,}000 = 16{,}333 \text{ ohms};$$

so that in this case the insulation resistance of the whole of the – side of the circuit comes out to 16,333 ohms.

(To be continued.)

ON THE DESIGN OF ELECTROMAGNETS FOR SPECIFIC DUTY.*

BY E. R. CARICHOFF.

Exigencies demanding the design of an electromagnet to perform a specific duty where maximum efficiency was necessary, and no experimenting permitted, the writer made some preliminary calculations, and found that with certain conditions the best results were obtained by reducing the polar area, and with other conditions the best results were obtained by increasing the polar area. After going through the excellent work of S. P. Thompson on the electromagnet, and not finding there or elsewhere any formulated statements showing the proper relation that should exist between the magnetic reluctance of the air-gap and the iron of the magnet, the writer tabulated a lot of results, and finally hit upon the following easy method of determining the relative air-gap and iron reluctance in order to get the maximum work out of a given magnet, where work equals initial pull times travel.

The writer offers this with the belief that it is entirely original, although it seems strange that so simple a relation has never been pointed out before.

To explain the method, let us assume, for example, that the curve in Fig. 1, O E C D, represents our iron, and O F our air-gap characteristic, and that we are working at the point C on said curve. Reduce the polar area A by d A, and suppose that the force is reduced for an instant by $d\mathfrak{F}$, so that the induction in the air-gap is still $\mathfrak{B}$, and that in the iron is reduced by $\Delta\mathfrak{B}$. Since a tangent drawn to the curve at C is parallel to the line O F, we see that the force

* From the *Electrical World* (New York).

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necessary to produce a change $\Delta \mathfrak{B}$ in the induction is the same in both iron and air-gap. Therefore, if $d\mathfrak{F}$ produces in iron a change $\Delta \mathfrak{B}$, it can produce $^1/_2 \Delta \mathfrak{B}$, say $d\mathfrak{B}$ in both.

It is evident that with the above assumptions

$$\frac{\Delta \mathfrak{B}}{\mathfrak{B}} = \frac{d\,A}{A} \text{ and } d\mathfrak{B} = {}^1/_2\,\mathfrak{B}\,\frac{d\,A}{A}.$$

With area A and induction $\mathfrak{B}$ the pull is proportional to $\mathfrak{B}^2$ A.

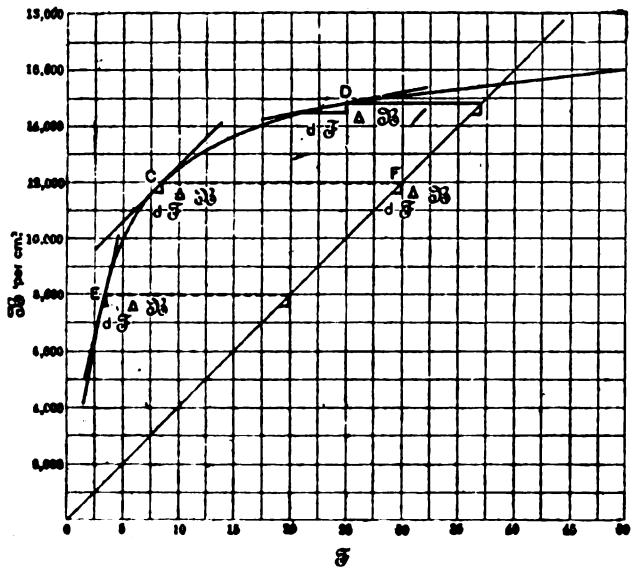

FIG. 1.

With the area $(A - d\,A)$ and the induction $\mathfrak{B} + d\mathfrak{B}$, we have $(\mathfrak{B} + d\mathfrak{B})^2 (A - d\,A)$ proportional to pull.

Then

$$\mathfrak{B}^2 A <=> (\mathfrak{B} + d\mathfrak{B})^2 (A - d\,A) \quad . \quad (1)$$

if $^1/_2\,\mathfrak{B}\,\frac{d\,A}{A} <=> d\mathfrak{B}$.

Since for this case $d\mathfrak{B} = {}^1/_2\,\mathfrak{B}\,\frac{d\,A}{A}$, the two sides of the equation are the same and the pull is the same when the polar area is A and when it is $A - d\,A$. In the same way it can be shown that the pull is the same where the polar area is A and $A + d\,A$.

From this we draw the conclusion that when the air-gap reluctance is expressed by a line parallel to the tangent drawn at the part of the iron characteristic where we are working, there is no gain by either increasing or decreasing the polar area. This is evidently the condition of maximum efficiency, as we shall see from further considerations.

Keep the same characteristics and suppose our ampere-turns put us at the point D on the iron curve. Decrease the polar area by $d\,A$, and for an instant the force by $d\mathfrak{F}$, so that $\mathfrak{B}$ is still the induction in the air-gap. $d\mathfrak{F}$ is now much greater than before necessary to make the change $\Delta \mathfrak{B}$, so that it will produce a change in the whole circuit by an amount, $d\mathfrak{B}$, referred to air-gap, where $d\mathfrak{B}$ is greater than $^1/_2 \Delta \mathfrak{B}$, or greater than $^1/_2\,\mathfrak{B}\,\frac{d\,A}{A}$. This condition makes the right-hand member of equation (1) greater than the left-hand member, showing that the pull is increased by decreasing the polar area. Increase the polar area by $d\,A$, keeping other conditions as above, and equation (1) shows that the pull is decreased. Therefore, if our iron curve shows that $\frac{\Delta \mathfrak{B}}{d\mathfrak{F}}$ is greater than the same function for the air-gap, the air-gap reluctance should be increased until the two functions are the same.

Again, at the point E we find that $d\mathfrak{F}$ is less than in the case first cited, and if the same reasoning is followed it is found that the pull is increased by increasing the polar area.

Instead of increasing or decreasing the polar area, the same results are gotten by shortening or lengthening the air-gap. When this is done, so that the function $\frac{\Delta \mathfrak{B}}{d\mathfrak{F}}$ is the same for iron and air-gap, the pull multiplied by the distance is a maximum. This being the case, the best results are obtained by using the proper air-gap; and if this distance is not the travel required, a lever can be used to multiply or divide with.

With these principles in view, it is easy to get the most efficient possible arrangement. It is also easy to predetermine a magnet to pull required amounts in more than one point of its travel.

By drawing tangents to all points of the iron curve, and lines from the original parallel to these tangents, and intersecting these by horizontal lines, we get the curve of proper air-gap for all points of iron curve cut by said horizontal lines. See Fig. 2.

There are some other curves that materially reduce the labour in designing an electromagnet for a definite work.

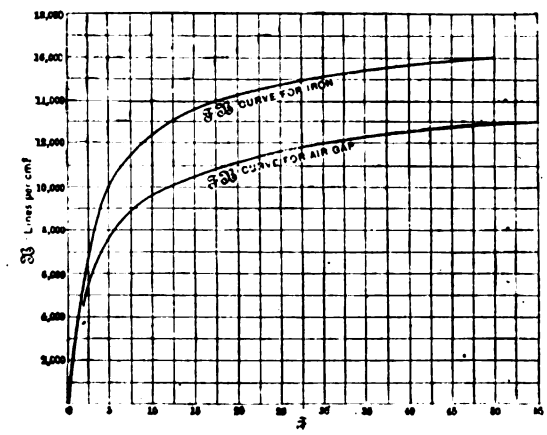
$\frac{\Delta \mathfrak{B}}{\Delta \mathfrak{F}}$ CURVE FOR IRON
$\frac{\Delta \mathfrak{B}}{\Delta \mathfrak{F}}$ CURVE FOR AIR GAP
$\mathfrak{B}$ Lines per cm²
$\mathfrak{F}$

FIG. 2.

To prove that the air-gap thus determined gives the maximum amount of work, which work equals initial pull times length of gap, change l by $d\,l$; then

$$\frac{\Delta \mathfrak{B}}{\mathfrak{B}} = \frac{d\,l}{l}.$$

We see that for the point F

$$\frac{d\mathfrak{F}}{\Delta \mathfrak{B}} = \frac{d\mathfrak{F}}{\Delta \mathfrak{B}},$$

and $$d\mathfrak{B} = \mathfrak{B}\,{}^1/_2 \Delta \mathfrak{B},$$

and for points to the right of F,

$$d\mathfrak{B} > {}^1/_2 \Delta \mathfrak{B},$$

and for points to left of F,

$$d\mathfrak{B} < {}^1/_2 \Delta \mathfrak{B}.$$

In the three cases the work will be proportional respectively to

$$\mathfrak{B}^2 l \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$
$$(\mathfrak{B} - d\mathfrak{B})^2 (l + d\,l) \quad . \quad . \quad . \quad . \quad (2)$$
$$(\mathfrak{B} + d\mathfrak{B})^2 (l - d\,l) \quad . \quad . \quad . \quad . \quad (3)$$

$$(1) - (2) = + \text{ for } d\mathfrak{B} > {}^1/_2\,\mathfrak{B}\,\frac{d\,l}{l};$$

$$(1) - (3) = + \text{ for } d\mathfrak{B} < {}^1/_2\,\mathfrak{B}\,\frac{d\,l}{d\,l}.$$

NEW MAIN SWITCHBOARD—CARNABY STREET STATION.

Everyone knows that the St. James' and Pall Mall Electric Light Company is looked upon as obtaining the very cream of electric lighting work, the district served being small, yet requiring a great number of lights almost constantly in use. Of course this led to the adoption, and very successful use, of a continuous-current low-voltage system of supply, though in order to save expense upon street mains the three-wire arrangement of distribution is in force.

At the Carnaby-street station of this company, Messrs. Siemens Bros. and Co., Limited, are now engaged in erecting a large new main switchboard from their own design and workshops, which appears to be

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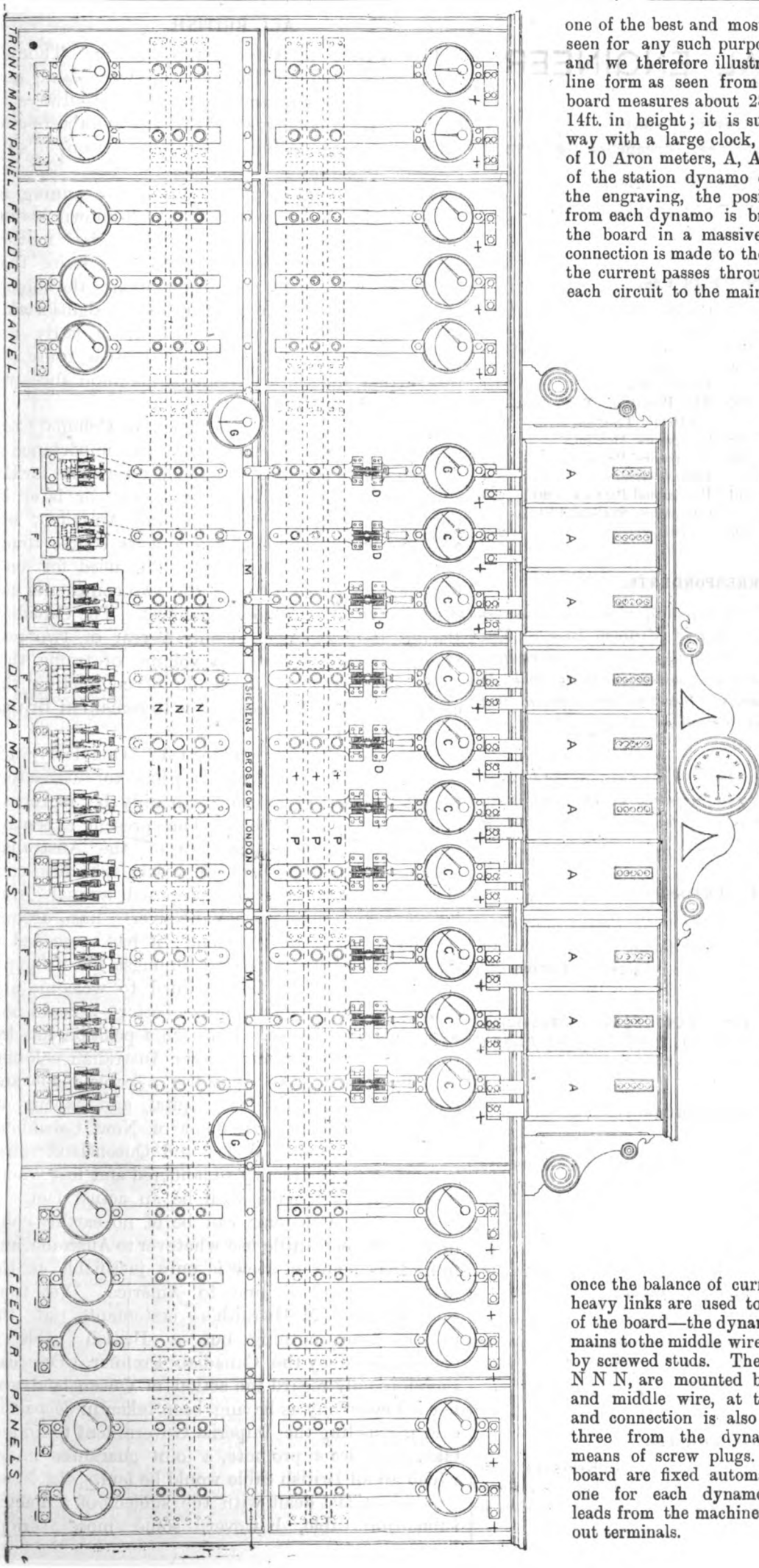

New Main Switchboard—Carnaby-street Station, St. James' and Pall Mall Electric Light Company, Limited.

one of the best and most compact we have yet seen for any such purpose as that in question, and we therefore illustrate it herewith in outline form as seen from the front. The entire board measures about 28ft. in length by nearly 14ft. in height; it is surmounted in the usual way with a large clock, beneath which is a row of 10 Aron meters, A, A, A, etc.—one for each of the station dynamo circuits. As shown in the engraving, the positive main, marked +, from each dynamo is brought to the front of the board in a massive terminal, from which connection is made to the meter above. Thence the current passes through an ammeter, C, for each circuit to the main switch, D, thence to a solid bar pierced with three holes, through any of which a large contact plug may be screwed into three positive omnibus bars at the back of the board, shown by the dotted lines in the illustration, and marked P. From these the current is taken as required to any of the feeder circuits by similarly coupling them up with screw plugs, or it may pass into the trunk mains connecting this station with that at Duke-street—also belonging to the St. James' and Pall Mall Company—either station thereby helping the other. Ammeters are provided for these circuits — feeder or trunk main—on both positive and negative sides. It will be noticed, however, that those on the trunk circuits are marked with their zero point in the centre of the scale, so that they show not only the amount of current passing, but also whether it is entering the station or leaving it, according as the ammeter needle is on one side or the other of zero. A similar type of ammeter is used on the middle or neutral bar, M, of the three-wire system, as shown at G. The engineer can see at once the balance of current either way. Short heavy links are used to connect—on the front of the board—the dynamo positive and negative mains to the middle wire, being fastened securely by screwed studs. The negative omnibus bars, N N N, are mounted below the positive bars and middle wire, at the back of the board, and connection is also made with any of the three from the dynamo negative bars by means of screw plugs. At the base of the board are fixed automatic cut-outs, F, F, etc., one for each dynamo circuit, the negative leads from the machines coming up to the cut-out terminals.

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THE
ELECTRICAL ENGINEER.

Published every Friday.
Price Threepence; Post Free, Threepence Halfpenny.
Editorial and Publishing Offices:
139-140, SALISBURY COURT, FLEET STREET, LONDON, E.C.

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TO CORRESPONDENTS.

All Rights Reserved. Secretaries and Managers of Companies are invited to furnish notice of Meetings, Issue of New Shares, Installations, Contracts, and any information connected with Electrical Engineering which may be interesting to our readers. Inventors are informed that any account of their inventions submitted to us will receive our best consideration.

All communications intended for the Editor should be addressed C. H. W. BIGGS, *139-140, Salisbury Court, Fleet Street, London, E.C. Anonymous communications will not be noticed.*

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Vol. XII. of new series of "THE ELECTRICAL ENGINEER" can be had bound in blue cloth, gilt lettered, price 8s. 6d. Subscribers can have their own copies bound for 2s. 6d., or covers for binding can be obtained, price 2s.

ALL BRITISH.

The arrival in this country of Sir Thomas McIlwraith, the late Premier of Queensland, and now Chief Secretary and Secretary for Railways in that important colony, affords us a favourable opportunity of again dealing with the question of submarine telegraphic intercommunication between Canada and Australia; of incidentally joining in the cordial welcome which this well-known statesman will doubtless receive from the mother country, and of expressing a fervent desire that his visit may help to bring about the object of which every right-minded and straightforward Englishman will approve when it is fairly put before him—viz., that of an all-British route for this further link in the bond of common ancestry, speech, and civilisation.

Six years have now passed since the Colonial Conference emphasised unanimously the importance of using not only the shortest and cheapest route for the submarine cable (which must sooner or later be put down between Australia and America), but also one which should throughout its course touch nowhere but on British soil. The need for such further intercourse between the two continents had even at that date become manifest. The Canadian Pacific Railway—opened only a year or two previously—already showed a volume of traffic that spoke very strongly in favour of completing the connection in such a manner as to remain in British hands throughout.

Since then, what has happened? One delay after another has led in some respects to satisfactory results; in others to what can only be regretted, and amended if possible. The present expensive monopoly (under which five of the Australian colonies alone have paid in yearly subsidies considerably more than the proposed annual grant for a new cable *viâ* Vancouver) has accomplished at least one good end: it has succeeded in creating such dissatisfaction amongst the principal colonists that they feel inclined to welcome any change as being likely to prove better—it could not, apparently, be worse. But such a position has led to the regrettable fact of two Australian colonies actually agreeing to subsidise a cable made and laid wholly by French capital and labour as far as the French settlement of New Caledonia. Surely New South Wales and Queensland must look upon this as money squandered and lost whenever the through cable shall be an actual fact. A line to New Caledonia can be of no earthly commercial or mercantile use whatever to Australia, and from that point of view is only justifiable as the first portion of a line to America. Yet from Sir Thomas McIlwraith's statements, at the present time nothing but a British cable is contemplated by the Canadian Premier. One can therefore only regard the action of Queensland and her fellow-colony as having been taken in despair of ever persuading the Imperial Government to undertake, or at least promote, a joint guarantee under which an all-British cable would be laid.

Since we last dealt with the subject of a Pacific submarine cable, however, some more serious

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attempts have been made to arouse concerted action; and foremost amongst those who have exerted themselves in the matter has been Mr. Sandford Fleming, C.E., formerly engineer to the Canadian Pacific Railway. Mr. Fleming has spent many months in the Australian colonies, bringing the question in every detail before the responsible heads of government; a similar visit has been paid by Mr. Bowell, the Canadian Minister of Trade and Commerce; and whilst thus endeavouring to arrange for united action at one end of the line, they have not forgotten to set the matter clearly before the Imperial Government at the other end.

As a result of their efforts, it is pleasing to hear that in June next an inter-colonial conference will be held at Ottawa for the express purpose of considering the whole question, and, if possible, of arriving at some definite and unanimous conclusion. If their present frame of mind should continue (Sir Thomas McIlwraith, for instance, has expressly declared that the Queensland Government declines to be a party to the monopoly of the Eastern Extension Telegraph Company, and aims at a policy of free hand, even to the extent of subsidising a second cable), the Australian colonial Governments, aided by the cordial goodwill and hearty approval of Canadian statesmen, may safely be relied upon to arrive at so definite and clearly defined a position in the matter that the Imperial Government will find itself absolutely compelled not merely to approve of the proposed step, but to support it in such a manner as to secure its success at no very remote period.

CORRESPONDENCE.

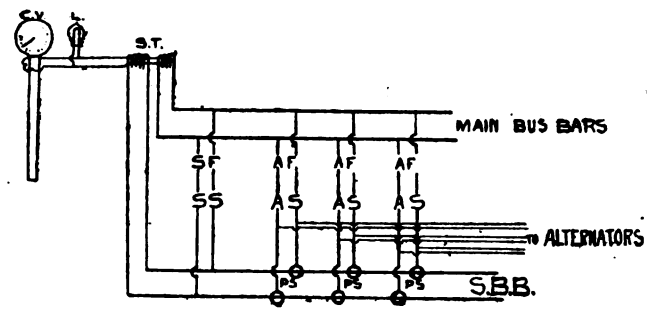
"One man's word is no man's word,
Justice needs that both be heard."

THE RUNNING OF ALTERNATORS IN PARALLEL.

SIR,—As there still appears to be a want of more general knowledge as to the facility with which alternators may be run in parallel, a few remarks as to such running at this station may be of interest to your readers, and serve to correct the erroneous impression that would be received from the remarks of "A Member" of the Northern Society of Electrical Engineers, as published in the report of their recent meeting.

Whenever more than one alternator is running on the mains of this station, they of necessity run in parallel. During the past winter, alternators have been put in parallel on an average of nine times per week. There has never been any difficulty in running, and there is no danger of an accident due to large synchronising currents in switching in parallel in the ordinary way if due care is taken; and if the method is adopted which I have in practice here, it renders an accident due to carelessness or nervousness at the moment of switching in impossible. The method adopted is as follows.

If alternator No. I. is running on the mains, A S 1 being closed, and it is desired to put alternator No. II. in parallel with it, the plug switches, P S 1, P S 3, must be out, the synchronising switch, S S, be open. The synchronising fuses, S F, must be of suitable size—that is to say, of such a size that any quantity of current passing that would be in any way injurious to either of the machines, or that would be liable to cause any noticeable variation in the voltage on the mains, would cause the fuses to blow. Then start up alternator No. II., and put in the plug switches, P S 2; the synchronising lamp, L, and the Cardew voltmeter, C V, will then record the effective voltage given by the synchronising transformer, S T. When the oscillation of the voltmeter needle is slow, showing that the machines are about their correct speeds relatively, watch for an opportunity when the needle has nearly attained the maximum reading, and then close the switch



S S; this will place the machines in parallel on the mains through the small fuses, S F. If the synchronism is unsuccessful, these fuses will blow, and the operation must be repeated with a fuse of 20 to 30 amperes—viz., three strands of No. 33 S.W.G. tinned copper; this need, however, never occur, but if all is well close alternator No. II., switch A S 2, and then open the synchronising switch, S S, and the plug switches ready for the next occasion.

In this way, I have put two 88-kilowatt Siemens-Willans alternators in parallel through a five-ampere fuse twice in three attempts without the fuse blowing. When using such a small fuse, however, it is necessary to run the incoming alternator on the stop-valve, as, if it were run on the governor, it would probably take a portion of the load as soon as the synchronising switch is closed, and then an excessively small fuse would give way.

If the governors are properly cleaned the current passing between two alternators in parallel, either two of 88 kilowatts, two of 210 kilowatts, or one of 210 and one of 88 kilowatts, as shown by the ammeter, does not exceed one ampere, and often no movement of the ammeter needle can be detected.

Machines should be paralleled when the voltage given by the synchroniser is on the increase; *never when decreasing*; and preferably not when stationary.

The only inconvenience that has ever been experienced in putting machines in parallel at this station has been due to the time it may take to get the machines running in synchronism should the load come on very suddenly, and the running machine so much overloaded as not to be able to keep speed. The risk of incurring this inconvenience will, however, I anticipate, be entirely overcome shortly.—Yours, etc.,

H. FARADAY PROCTOR,
City Electrical Engineer, Bristol.

Feb. 26, 1894.

THE MOUNT LOWE CABLE RAILWAY (SOUTH CALIFORNIA).

SIR,—With reference to the notice of the above electrically-worked railway in your last week's issue, may I say that that line is evidently more or less an exact copy of several such lines in Switzerland, and that as regards altitude the Marren electric railway (5,000ft. above sea-level) beats it by at least 1,900ft.)?—Yours, etc.,

C. S. DU RICHE PRELLER.

18, Margaret-street, Cavendish square, W.,
February 28, 1894.

THE LIVERPOOL OVERHEAD ELECTRIC RAILWAY.

At the ordinary meeting of the Institution of Civil Engineers, on Tuesday, February 27, Mr. Alfred Giles, president, in the chair, two papers were read relating respectively to the construction and the electrical equipment of the Liverpool Overhead Railway.

The first paper, entitled "The Liverpool Overhead Railway," by Messrs. J. H. Greathead and F. Fox, MM.I.C.E., began with a history of the undertaking, which was the practical solution of a difficulty first experienced 40 years ago—namely, the provision of better communication for passengers along the frontage (now

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extending to 6½ miles) of the Liverpool Docks. The elevated railways in New York had been highly successful in meeting the wants of the travelling public, but were attended by several inconveniences. There were no parapets and no floors, the sleepers being placed directly on the top flanges of the girders. The result was that, as the railways were worked by steam locomotives, cinders, oil, and water dropped into the street; fine shavings from the rails and tyres fell on the foot passengers, and, in one case at least, a locomotive had fallen bodily into the street. Mr. A. G. Lyster, who had minutely studied the New York system, and reported thereon to the Liverpool Corporation, had expressed himself in favour of an overhead electrical railway, and after some delay an Act was obtained in 1882 by the Mersey Dock Board for the construction of a double line of 4ft. 8½in. gauge. The estimate for this, fully equipped and worked by electricity, was £466,000. The structure was intended to consist of plate girders, with overhanging continuous footways having parapets of iron lattice-work, with the rails laid upon greenheart planking; the whole being supported by columns of partial lattice-work placed in the normal structure, one on each side of the lines of dock railway. Owing to the fact that many influential members of the Dock Board were unwilling to embark upon railway management, the undertaking was in 1887 leased to the present Liverpool Overhead Railway Company, by which the line was constructed.

The length of railway at present worked was five miles, but would ultimately be 6½ miles. In the structure decided upon the columns were placed vertically under the ends of the main girders, about 22ft. apart from centre to centre, allowing sufficient width for two lines of standard gauge with the usual 6ft. way, and admitting the use of carriages 8ft. 6in. wide. Local circumstances in many cases did not, however, admit of the columns being placed immediately upon the main girders, and the latter were then carried upon cross-girders outside the line of columns. For considerable lengths, also, the columns had to be embedded in the boundary and warehouse walls. Owing to the presence of the dock lines below, cross-braeing of the piers in the usual way was impossible, and it was necessary to give to the columns and to the shallow cross-bracing connecting them at the top sufficient strength and rigidity to resist the lateral stresses due to wind pressure, and, on curves, to the centrifugal force resulting from the motion of the trains.

In carrying out the works no special difficulties arose in connection with the foundations of the piers. In places where rock was not reached, masses of concrete were deposited of sufficient extent to ensure the maximum load on the base not exceeding one ton per square foot. In excavating for the foundations the sill of the first dock made in Liverpool was discovered, and several lengths of old water-pipes, consisting of trunks of trees bored out and fitted together, were brought to light. Owing to the railway being placed immediately over the dock lines, the latter were in many cases diverted, straightened, and improved. The columns supporting the viaduct consisted of two steel channel bars riveted to two steel plates, forming a box column with all the rivet-heads outside. These columns were grouted into cast-iron sockets bedded in and bolted through the blocks of concrete. Cast-iron bumpers filled with cement concrete protected the columns from injury from passing wagons. The normal span was 50ft., but longer spans up to 98ft. and shorter ones of about 30ft. were required in some cases. Up to 75ft. span, the height of the girders above the rail-level did not exceed the platform height, and plate girders were used. In longer spans bowstring girders were used. Between the girders was fixed Hobson's arched-plate flooring, consisting of $\frac{5}{16}$in. plates bent to a radius of 12in., with a flat surface 6in. wide on the top, riveted to intervening T-bars, and made watertight by asphalte run in the V-channels between the arches. The structure was so designed that the spans could be put together and riveted up with floor complete at one or both ends of the railway, and be then transported over the completed portion of the structure to be placed in position. A special form of erecting-machine was provided, consisting of two lattice girders standing upon legs resting on the ground at the front end, and at the hinder end upon a carriage running on rails on the viaduct. These girders were placed at such an altitude as to allow the trolley carrying the succeeding span to be rolled along underneath them. On these lattice girders were placed two travelling cranes, so arranged as to lay hold of the spans on arrival, run them forward, and deposit them in their permanent position upon the columns which had been erected in advance. The average time occupied by this operation was one hour per span.

In the course of the work several opening bridges had to be provided which were described and illustrated in the paper, as were also the stations, permanent way, and rolling-stock. The total quantity of iron and steel in the structure was about 22,000 tons. The total capital cost, including equipment and all other charges, had been £550,000, or about £90,000 per mile of railway. The line was formally opened by the Marquis of Salisbury on February 4, 1893, and was opened for traffic on March 6 following. The electrical system of working was completely successful, a five-minute service of trains being maintained with perfect regularity and without mishap of any kind. On the last August Bank Holiday about 40,000 passengers were carried in the space of eight hours.

The second paper was entitled "The Electrical Equipment of the Liverpool Overhead Railway," by Mr. T. Parker, M.I.C.E.

The plant was required to run a three-minute service on six miles of double track. In designing it, curves were drawn of the energy required at any point along the line of one loaded train with various accelerations, etc., to meet the time-table service. From these curves the power required at the generating station was calculated, and four dynamos were arranged for, yielding 475 amperes at 500 volts and 420 revolutions, or 1,200 e.h.p. in all. The dynamos were of the double-line type, rope-driven, with pulley between two bearings, so that the armature could be taken out without disturbing the ropes. The electrical efficiency of the dynamos was 97·77.

The switchboard, specially designed for safety and simplicity in working, was fully described. The main current passed to the line though a main magnetic cut-out to break circuit at 3,000 to 4,000 amperes. The conductor was of steel, four square inches in section, supported on porcelain insulators. There were no feeders, and the return circuit was through the rails, which were bonded. At each station there was a cross-over road. The conductor was broken at these points, and the collector bridged across over the main rails without breaking circuit. It was necessary that the cars should be of the double-bogie type; it was, therefore, difficult to design motors to give the power necessary on standard bogie frames. Finally a type was adopted, as patented by Mr. Eickemeyer, which gave complete satisfaction. The motor occupied the front half of the bogie truck. The weight of the magnets was taken off the axles by adjustable springs, and the magnets were kept in horizontal position by a lever arm fixed to the bogie frame. Each car was complete with motor and switch gear to run independently. Two cars were coupled together to form a train. Either the driving or trailing motor could be pulled out of circuit at will. A Westinghouse air-brake was attached to the car; also the usual hand-brake. The stations were lighted by 50-volt incandescent lamps, run off accumulators fixed at the station and charged from the main dynamos.

The efficiency of indicated horse-power to electrical horse-power on the line was taken with carefully-calibrated instruments in the presence of the engineers. The tests extended over three and a half hours. The mean value of seven tests of No. 1 engine gave 88 per cent. indicated horse-power to electrical horse-power. Curves were given of the power consumed during an experimental run of one train completing 5⅛ miles in 24 minutes 57 seconds, and 23 minutes 47 seconds, with stops of 25 seconds at each station. The power required was 44·4 i.h.p. and 46 e.h.p. respectively. To compare this with actual running, curves were given from daily log-sheets showing the effects on the generating station of the alteration to the train service. The advantage of a large number of trains in pulling down the maximum current per train was

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apparent. With seven trains this was twice and with 12 trains only 1½ times the average current per train. With 12 trains running, the average demand for power continuously was 37 e.h.p. per train.

A comparison of coal used when the train service varied was given. During April and part of May seven trains were running at one time, and the coal used was 22·5lb. per train mile. From June to October there had been a five-minute service from 9 a.m. to 5.30 p.m. The coal used per train mile for the four months of June, July, August, and September was 17·8lb., or making allowance for charging batteries, say 17lb. per train mile. The price of the Lancashire slack, which was used till the latter part of August, was 5s. 10d. per ton, but since that date, owing to the strike, the price for coal from various sources had varied up to 17s. 6d. per ton. Under the agreement, the contractors had to run the service of trains for 3½d. per train mile, on a full service of 2,400 miles per day, but as only 5⅛ miles of line were open they received 4d. per train mile, and for current to charge lighting batteries 7d. per Board of Trade unit. Figures were given of the actual working costs for July, August, and September, 1893, which were 3·44, 3·70, and 4·07 pence per mile respectively. The increased cost of running for August and September was fully accounted for in the item of coal, and as the railway company had not employed as frequent a service as at first anticipated (this being only 1,350 miles per day), the figures showed most favourably, it being evident that with coal at an average value, the line could be run at a cost well within that guaranteed by the contractors.

TESTING THE MAGNETIC QUALITIES OF IRON.

In our last issue we reproduced the paper read by Mr. Gisbert Kapp before the Institution of Electrical Engineers "On Methods of Testing the Magnetic Qualities of Iron." References were therein made to three wall diagrams, which we now give herewith.

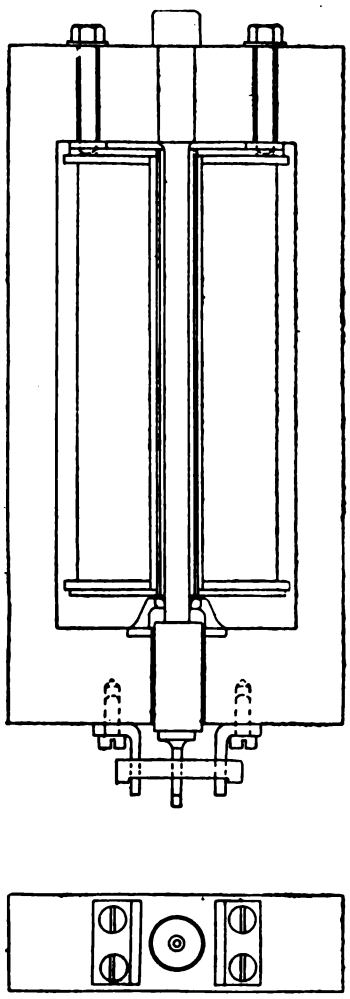


FIG. 1.—Testing Machine for Iron Bars.

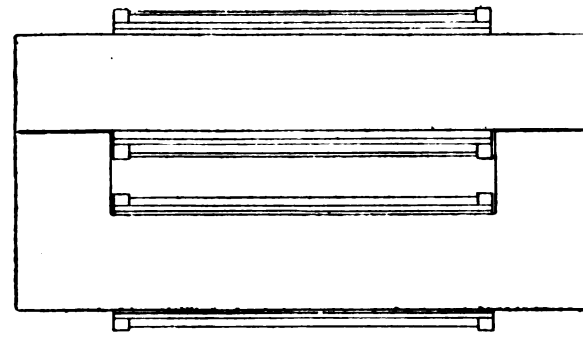


FIG. 2.—Testing Machine for Transformer Plates

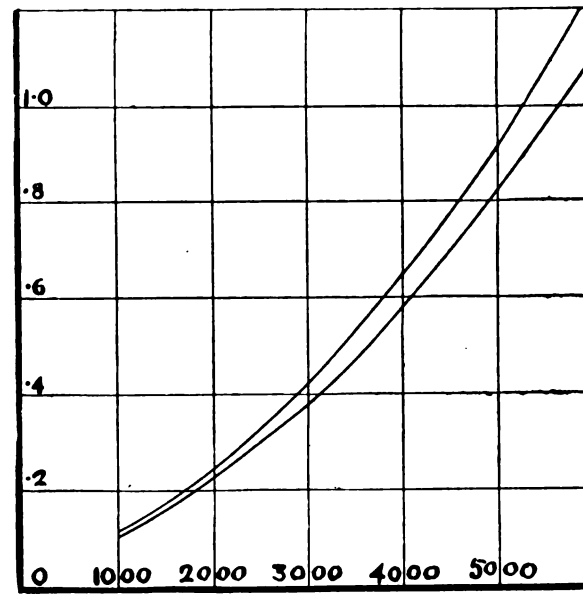
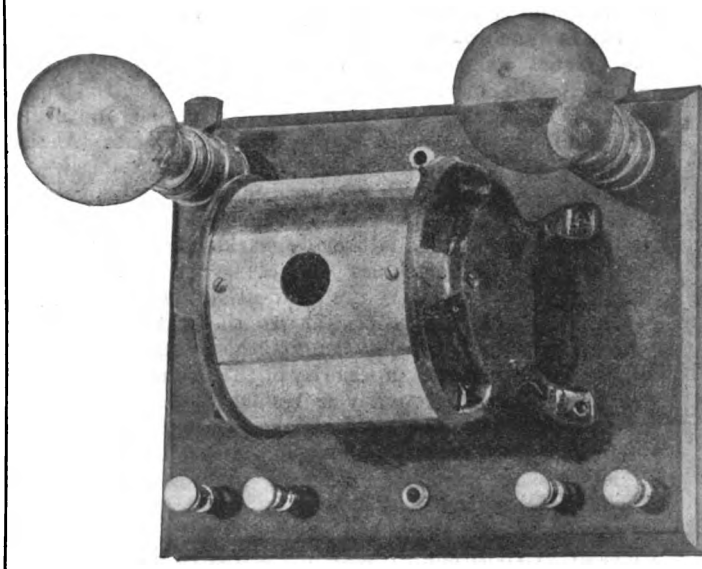


FIG. 3.—Diagram showing Average Results obtained in Testing Samples of Plates.

ACOUSTIC SYNCHRONISER FOR ALTERNATORS.

With the great use of alternating-current machines, and with our modern ideas of central-station practice, it is frequently desirable to run alternators, single-phase and polyphase machines, in parallel. Although alternators



Acoustic Synchroniser for Alternators.

have not hitherto been run in parallel as a general thing in the United States, the practice is not infrequent in Europe, where it has been made the subject of much study. The operation of alternators in parallel is, however, receiving more attention in America, and a device to indicate in the most delicate, yet effective, manner the exact point of synchronism in speed and coincidence of phase of two alternators has become a necessity. The requirement is

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met by the acoustic synchroniser, which the General Electric Company of New York have recently brought out, and who send us the following description. It consists merely of a cylindrical iron case with an aperture in the side, each end being closed by flexible diaphragms, each of which has opposite its centre the pole of an electromagnet. In using this device one of the magnets is connected in circuit through a transformer with each of the machines to be run in synchronism. The current is then turned into the magnet coils, and the diaphragms emit a loud clear note. As the machines approach synchronism, the notes from the diaphragms approach closer in period and begin that loud, periodic sound known in music as beats. As the two machines more nearly approach synchronous speed, the beats grow slower and slower, until finally the diaphragms fall into unison and each gives out the same low, clear note. At this moment, which is sharply marked, the switch connecting the two machines should be thrown in. So sensitive and distinct is the indication of approach of synchronism, that it is possible to throw two machines together with hardly a quiver upon the ammeter in actual circuit. The immense superiority of this acoustic apparatus over the old phase lamp device cannot be disputed. It is much more sensitive, indicating distinctly the small differences from synchronism which the phase lamp fails to detect.

The synchroniser was shown by the General Electric Company in its power and mining department at the Chicago Exposition, where it attracted considerable attention, especially from foreign electricians. When it was shown to Prof. von Helmholtz, and its operation explained, he expressed himself delighted. It was a development in his own field of acoustics, and showed how electricity and acoustics could work together for scientific benefit.

SOME NOTES ON THE ELECTRIC LIGHTING OF THE CITY OF LONDON.*

BY MAJOR-GENERAL WEBBER, R.E., C.B.

(Continued from page 237.)

The facility, or otherwise, of obtaining sites for transforming stations could not be fully gauged during the preliminary stage, and space underground to be found for large conductors could only be expected to a very limited degree. If we had only known as much as experience has since shown, it is quite possible that a continuous-current system of distribution would have had as good a chance of being adopted as the alternating system. Distribution with low pressure from transforming stations entailed a network on the well-known lines, with distributing service mains and feeders. When the time arrived for the City to be divided into areas, each to be served by a transforming station, with all the stations, if not the areas, intercommunicating, the areas and points for the stations had to be approximately assumed, and the number of ways estimated that would be required under each footway throughout the whole City. It would have been, of course, easier to have first found sites for the sub-stations and then arranged the areas to be served by them; but as the main thoroughfares traversed the City throughout in all directions, there was no area that was not touched by the work requiring immediate completion, so that to be able to get the above-named 17 miles done all had to be considered in advance. The combination of casings with 1¼in. and 2¼in. pipes (see samples exhibited) require a minimum sectional area of trench varying according to locality, and if the soil below the footways had been comparatively free there would have been little difficulty in aranging the position of the ways relatively to one another, so as to suit all requirements. It was essential (*a*) to place them so that the relative positions of the ends should coincide at any rate between box and box, no matter what might be their vagaries in the interval; (*b*) that, when the trench was opened alongside of a line of pipes enclosing telegraph conductors, the mass of the iron pipes should be laid between the alternating low-pressure conductors and the same, to aid in screening the inductive effect on the smaller currents; (*c*) that the ways destined to be used for the arc lighting, and for the distribution in the street itself, should be nearest the surface. As it was, the fulfilment of these and all other conditions I have mentioned was often absolutely impossible.

The obligatory positions of boxes for drawing in and out and for access to the cables (exclusive of house service and street lamp boxes, which were only for access to the cables required) were numerous, as it was necessary to place one at every street corner, and wherever a serious change of direction occurred. Still, the lineal space of line of main occupied by boxes was, on an average, only about two yards in every 100. These boxes were made as large as possible, which is not saying much; I aimed at making them large and deep enough for a man to get entirely inside, but this was rarely possible. Owing to the obstruction underground, they are of every conceivable size and shape. Drainage and access of gas from the surrounding soil are conflicting conditions. The drainage had to give way unless some nearer outlet was evident, and the boxes made as gastight as cement and glazed or impervious bricks could make them. This question of the presence of explosive mixtures in street boxes has, as my audience knows, been several times brought to notice by explosions—one lately in the western district, on Ludgate-hill. My own view of this particular condition of danger has been to do everything to prevent the coal-gas getting into a box, and I believe this can be secured with proper precautions, apart from the occasional possibility of being able to ventilate by in-draught and out-draught ducts. The precautions are (*a*) good joints between case and case, ensured by finally passing the red-hot "mouse" through each joint after the casing has been laid; (*b*) absence of air-space between the cases and the iron sheathing; (*c*) careful sealing-in

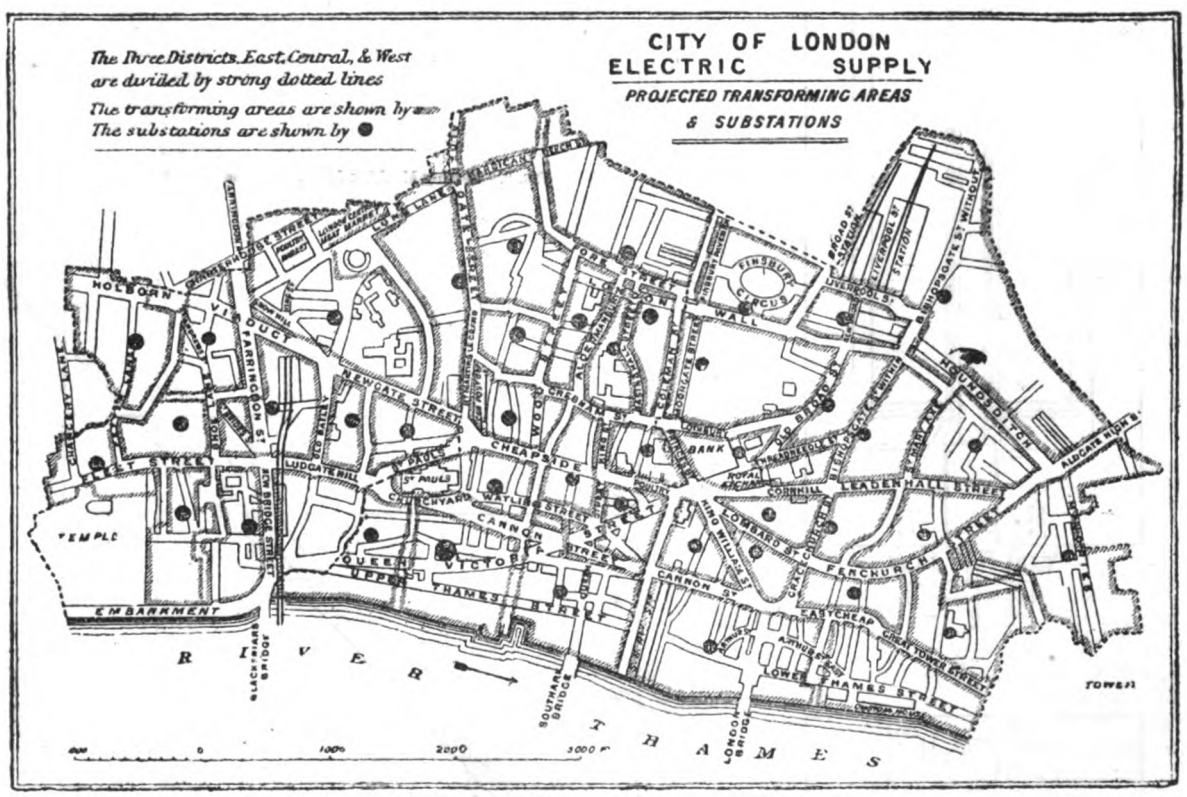

FIG. 11.—Map whole City, showing Points Transforming.

* Paper read before the Institution of Electrical Engineers.

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round the iron tubes and bitumen cases where they pass through the wall of a box; (*d*) careful plugging of all "ways" not in use, and caulking with tarred yarn round the cables where they emerge from the "ways"; (*e*) the use of drainage only where the pipes are sure not to become ducts for gas; (*f*) ordinary care in the use of lights until gas is clear.

The nature of the material in and shape of the frames of the iron covers were the outcome of some experience. Nothing is better than a wide rim to the frame, roughed to prevent slipping, filled in with fine Portland cement concrete made with very hard material, and allowed some weeks to set. The bad ones—and I see there are some—were the result of want of care and bad material. The wide rim provides space for letters indicating the

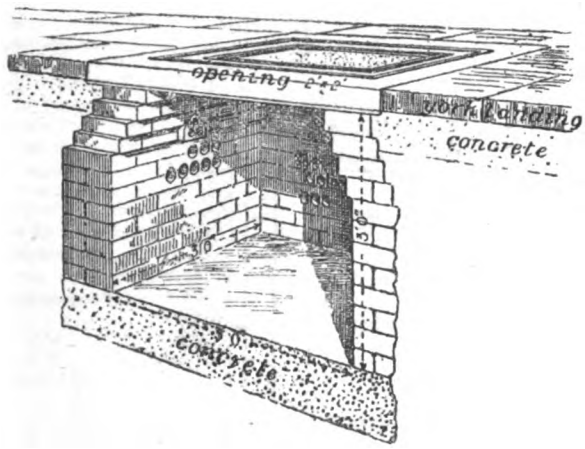

FIG. 12.—Example Street Box.

ownership of the box. In the trenches opened for that purpose all the conduits for conductors, the need for which in the future could be foreseen, had to be provided (*a*) for the public lighting high-pressure conductors, concentric in some length, separate in others (see samples of 1¼in. pipes); (*b*) for the private lighting primary high-pressure concentric conductors from the central to the converting stations, and between the latter (see samples of 2½in. pipes); (*c*) for the three-wire feeding mains to points in the network (see various sections of casing); (*d*) for the three-wire distributing low-pressure conductors of the network (see various sections of casing); (*e*) for the pilot or signal wires for the service of the company—one in each trench; (*f*) for spares and the future use of telephone conductors—as many in some places as 23—as the probable future demand indicated. (On this subject, from the point of view of the telephone service in London, I hope to be permitted to read a paper before the Institute at a future date.)

As an under-estimate of the number and size of these meant a waste later on, in having again to open the streets, and as an over-estimate would be also wasteful, it was imperative, as I have said, to make a careful study of the whole. This was done with an accuracy only diminished by the following: (*a*) the number of existing lights that might be expected within a given number of years to be replaced by incandescent lamps; (*b*) the selection of the boundaries of the areas, and approximately of the points for the transforming stations; (*c*) the desirability, though not an essential, of arranging the areas so that the difference between the consumption in each should not be too great.

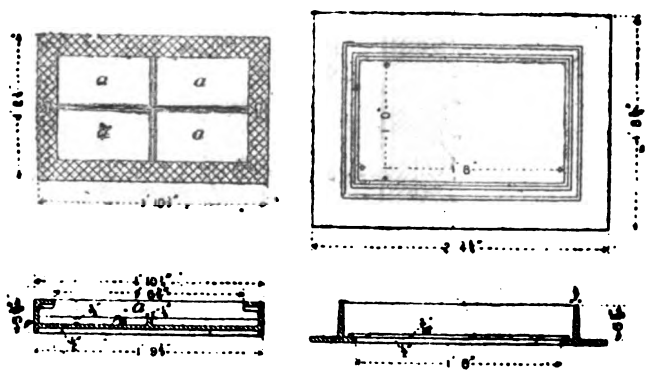

FIG. 13.—Example, Cover to Street Box.

To the difficulties in finding sites for stations, and to the unforeseen obstructions to be encountered underground generally, all these became subordinate. Careful canvassing of the City in various typical blocks of buildings (a "block" meaning all buildings situated between the nearest streets which meet one another) showed that they might be roughly classified in three, and that the number of existing lights or lamps, averaged as follows per square yard of ground space, was:

	Central.	Eastern.	Western.
First-class blocks, per square yard.	0·254 ...	0·275 ...	About the
Second-class ,, ,, ,,	0·171 ...	0·171 ...	same as the
Third-class ,, ,, ,,	0·067 ...	0·100 ...	central.

Another canvass led to the conclusion that the proportion of those existing lamps that might be expected to be replaced by incandescent lamps was:

In the first-class blocks	0·75
In the second-class blocks	0·50
In the third-class blocks	0·33

The above figures were applied, and the blocks being all classified and grouped in areas, so that each area might, as has been stated, have approximately the same number of lamps, the following results were obtained; and, although it will be a very long time before its general accuracy can be tested, I feel sure that, so far as the number of lamps is concerned, it is not very far from the truth, although the number of areas may vary very much from the estimate. For the three districts the following figures were arrived at:

INCANDESCENT LAMPS.

	Eastern.	Central.	Western.	Total.
18 areas	139,900	—	—	—
14 ,,	—	100,750	—	—
12 ,,	—	—	99,547	—
Total, 44 areas	—	—	—	340,197

If these are 8-c.p. lamps of 33 watts, this will give a load at the lamp terminals of 11,226·5 kilowatts. With 96 per cent. in the transformers at full load (the efficiency specified under the contract), and 5 per cent. loss in the mains, primary and secondary,*

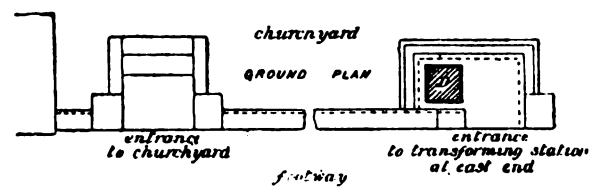

FIG. 14.

the output of alternating current of the three stations—namely, 12,100 kilowatts—is not far short of 12,236 demand, the maximum possible load, so that with 80 per cent. of the lamps alight there would be nearly 20 per cent. spare generating plant. If it may be assumed also that each 8-c.p. (33-watt) lamp uses 18 units = 6,123,546, with 20 per cent. spare, the load factor comes out = 13·8. The design of 44 converting points in those districts required that, including spares, each transformer station should have, on an average, 275 kilowatts capacity. The three first permanent sub stations, the sites of which were secured by, and the structures designed by, myself were: (1) Pancras-lane (Bennet shere-hog), with space for transformers having a capacity of 450 kilowatts; (2) Nicholas-lane (St. Thomas Acorn), with space for 480 kilowatts; (3) Queen Victoria-street (St. Nicholas Cole Abbey)—this is a double station, and has space for 648 kilowatts. Of these I only show the design of the first, it being situated under exceptionally difficult conditions. (See Plan No. 14, etc.)

TRANSFORMATION.

As has been said, little progress could be made with the selection of sites for permanent transformer stations before July, 1891, as the general scheme upon which their relative positions much depended was still under consideration. To distribute the current generated in the pioneer stations, three temporary transforming stations were improvised—viz, one in Queen Victoria-street, in the basement of No. 47; one in the basement of the Mansion House; one in St. Swithin's-lane, under a restaurant. In no case were these suited to become afterwards permanent stations, both on account of size and circumstances of surroundings. In the transformers first delivered the secondary windings gave a pressure of one-twentieth that of the primary; and as the current is delivered at an E.M.F. of about 2,050, and it had to be

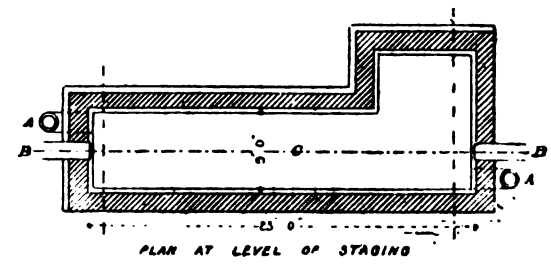

FIG. 15.

distributed in the three-wire mains with an initial pressure of about 205 volts, they had to be coupled two in series—an arrangement which would disappear with the delivery of the contract transformers.

It early became evident that the price, by way of rent, that would be demanded for adequate space in, and access to, existing buildings, was prohibitive in the more costly areas. For instance, in Lombard-street, where every square yard is said to be worth £1,000, it can readily be conceived that £500 a year was asked for a small room in the basement. With this in view it behoved us

* It is quite certain that this ideal condition of efficiency can only be achieved when a completed system is at full work lower loads it will often go down to 76 per cent.

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to look for what we required to the space under those portions accessible to the public, or not available for building purposes. Careful searching showed that many engineering and financial difficulties existed For instance, at some points where there was evidently ample space below the surface, a prohibitive price was asked for the means of access to it through private property; and, again, at many such points, space for access within the area used by the public could not be obtained, for various reasons of public convenience and safety. In time our attention was turned to the old City graveyards, and, after long negotiation with the parish authorities, and with the Consistory Court and the Commissioners, leave was obtained at a fair cost to use a small portion of two of these open spaces in Pancras and Nicholas lanes, so as to provide shafts for descent to the contiguous chambers to be constructed by leave of the Commissioners under the foot or road ways. But, even with this facility, the space below was in one case—namely, Pancras-lane—extremely limited, through the

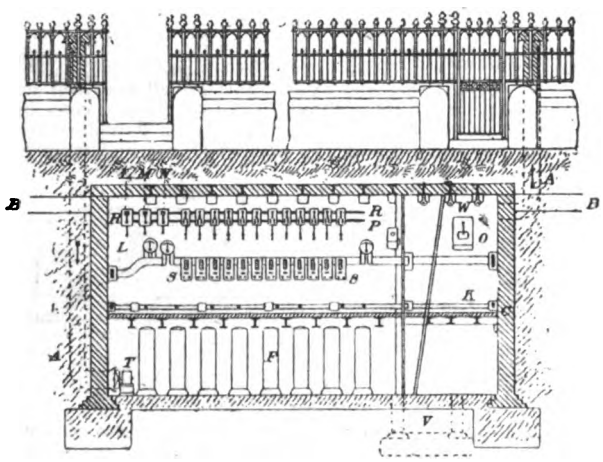

FIG. 16.

existence of large main sewers and water and gas pipes. In excavating, large quantities of human bones were met with, which had all to be transported carefully for extramural re-burial.

The drawing shows the structure and the conditions of housing the transformers and switchboards and connections. Under such circumstances every inch was important, and it was to the suggestion of my chief assistant, Mr. Nisbett, that the plan of placing the transformers, F, below the floor was adopted in that station. Height was the most elastic dimension, and it will be seen that the attendant standing over the transformers on a stage, C, has sufficient headway to stand up and attend to the board, S, one on the north, another on the south side. The floor of this stage is made of wooden squares, each of which can be taken off independently, and the top end of the transformer underneath exposed. When required to be removed, it is lifted by tackle suspended to a ring (as at W) in the arched roof, and, being received on to a

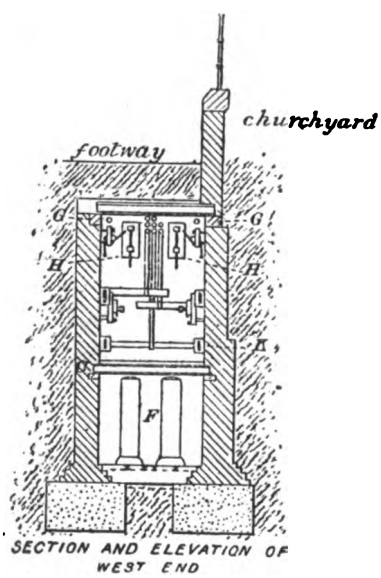

FIG. 17.

hand-truck, it is moved along the floor to the bottom of the entrance shaft, and there, by other tackle, carried by a tripod standing above on the dwarf walls, lifted up to the surface, where it can be lowered on to a suitable trolley and taken away. B shows where the conduits enter the station at the east and west ends; D is the entrance for access to the descent by ladder into the staging; F indicates the 18-kilowatt transformers; G, the position of the primary 'bus bars on each side; H, the main primary switches; K, the low-tension middle bar which runs round the tension; L and N are switches for connecting at high tension with other transforming stations; M, a switch to divide the station in two for repairs; O, a recording voltmeter; P, the telephone to the generating station; R, one pole of high-tension bar, with a switch to every two transformers, and Brush-Mordey fuses; S, low-tension switches on 'bus bar, with a switch to every two transformers, and separate fuses; T, motor and fan for ventilation. Drainage by a sump, V, and ventilation by large upcast and downcast shafts, A, A, are provided, as well as means of telephonic communication, P. The cost of the builder's part of the structure, when completed, is about £430, with an annual charge for the wayleave of about £5.

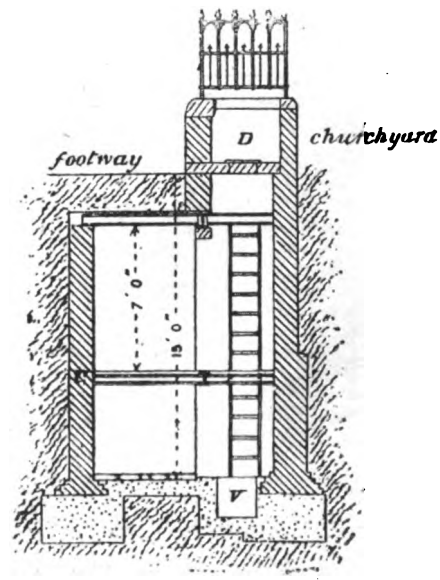

FIG. 18.

The honeycomb space under the staging floor should be able to receive 45 10-kilowatt transformers, of which 40 may be assumed to be in full use—the rest spare. The cost may be considered in the following way:

The present value of £5 a year for 21 years, at 5 per cent....	£64
Cost of building construction	430
Cost of transformers and fittings, as per contract.....	—
400 kilowatts, at £7 per kilowatt	2,800
Add 5 per cent. for supervision and contingencies	182
Total cost of a transforming station (having a maximum space for 450 kilowatts)	£3,476

To arrive at the capital cost of the plant between the generating stations and the low-pressure feeders, it is necessary to add the cost of two concentric mains; and this I have taken from a

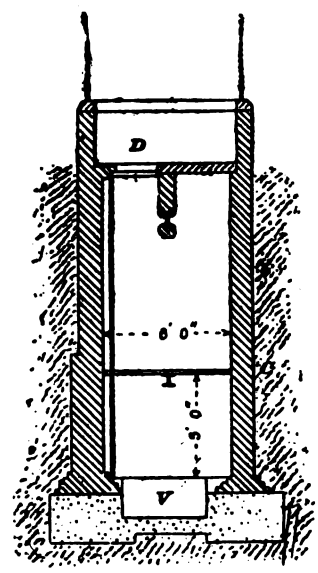

FIG. 19.

table that I prepared which enables me to appropriate with very fair accuracy between the conduits for various purposes the cost of the underground work. In this case the distance is about 1,200 yards.

Carried down	£3,476
Two 2½in. wrought-iron conduits, at 4s. 4d. per yard.....	520
Two 0·154in. concentric high-insulation 1,200-yard cables drawn in and connected	1,150
These figures give a total capital outlay of.....	£5,146

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which will be repaid, interest and principal, at 4 per cent. in 21 years by, per annum, £161 ; to which should be added at least 2½ per cent. depreciation and repairs—say £136—and £70 for attendance and small stores—total, £367. Again, assuming a total consumption of about 18 units per 33-watt lamp fixed, and 12s. the gross earnings per lamp per annum, and allowing 96 per cent. efficiency as before, and the equivalent of 15,000 8-c.p. lamps connected with this one station, or, say, £9,000 per annum, the above annual charge will represent 4 per cent., being a standing charge on every unit sold. A useful comparison may be drawn between the cost of these 2,000-volt mains and low-tension mains at 200 volts from the generating station to the same distributing centre. A loss of 2 per cent. in the high-pressure mains, and of 4 per cent. in transforming—total 6 per cent.—in the former, may be fairly balanced by a loss of 15 per cent. in the latter. The additional size of the low-tension plant is counter-balanced by its lower price. The low-tension main, required to carry 400 kilowatts at 200 volts pressure through 1,200 yards of distance with a loss of 15 per cent., would be about 4 square inches of copper in each outer conductor, and 2 square inches in the middle wire. Such a line, using the largest insulated cables made, and drawing them into 10 3in. "ways" of casing, would cost more than £15,660, representing an annual charge of £490, or 5·4 per cent. on each unit sold. Mr. Crompton will, I hope, give us the cost of the same sections of bare copper strip laid in culverts on his system, if he can keep his culvert within 160in. sectional area.

marked respectively, C^1, C^2, C^3, C^4, and E^1, E^2, E^3, E^4. The diagram map shows eight central districts in the City which were presumed to be those richest and having the largest immediate demand. He agreed entirely with me in deprecating the provision of mains through long streets, as had been laid out in the pioneer contracts, and saw the need to break up long streets into sections, each such section to be supplied as part of a compact surrounding area. The exact delimitation, even of the individual areas, he considered a less important matter than their compactness, solidity of work, and efficiency of supply. At that time, and with the same gentleman, the question of automatic switching of a bank of transformers was discussed. It was a novel one as regards experience. We regarded it as essential that, although at first manual regulation with daily shifts of attendants could not be avoided, eventually it would have, for economical reasons, to be done automatically. And in connection with this the inventions of Messrs. Gordon, Mordey, Tomlinson, Ferranti, and Kapp were considered. Of these well-known electrical engineers some are present, and will, I hope, give us the benefit of their remarks on this very interesting and important part of the subject.

Execution of the City Street Work.

Although it may not fall to the lot of any present to have to carry out a similar work under the same conditions, it seems to me that a short account of a portion of what was done in the City streets may prove instructive to engineers. Our papers are generally very full of technical interest, but few ever narrate the

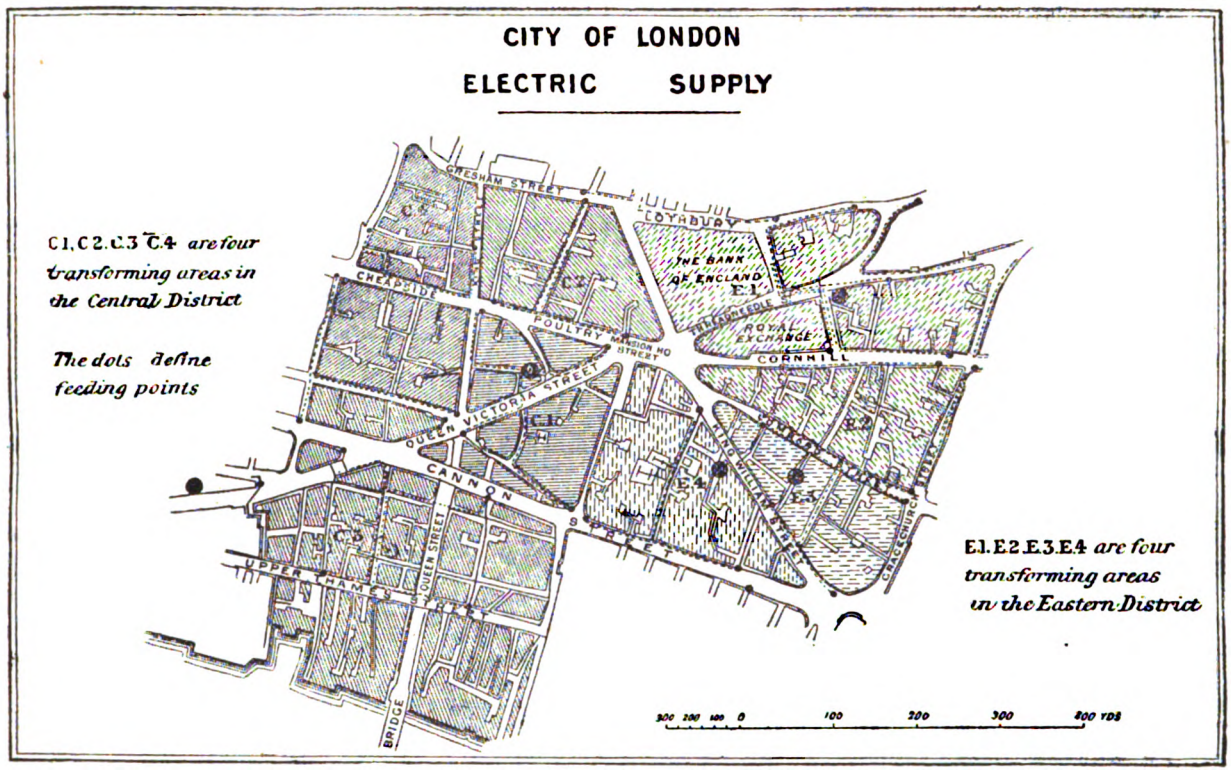
CITY OF LONDON
ELECTRIC SUPPLY
C1, C2, C3, C4 are four transforming areas in the Central District
The dots define feeding points
E1, E2, E3, E4 are four transforming areas in the Eastern District
GRESHAM STREET
CHEAPSIDE
THE BANK OF ENGLAND
ROYAL EXCHANGE
CORNHILL
QUEEN VICTORIA STREET
CANNON STREET
UPPER THAMES STREET
QUEEN STREET
BRIDGE
300 200 100 0 100 200 300 400 YDS

Fig. 20.—Centre of City.

It being very desirable that the works of distribution in the City should receive efficient criticism, Prof. S. P. Thompson was (at my suggestion) asked in October, 1891, to advise and report, which he did ; and I regret that circumstances permit me only to give the sense of his reports. He dwelt with the subject of any possible advantage from the use of low-tension dynamos and step-up transformers at the generating station, in comparison with the generation and transmission at 2,000 volts as specified, without recommending any change in the designs. He recognised the extreme difficulty, in certain thoroughfares, of getting ways for the laying of conduits ; in certain rich blocks, of getting a cellar for a distributing station ; and the necessity for the principal routes to run north and south, not east and west, because the generating stations were on the south side. As an example, he regarded Cheapside as practically an impassable street ; as it runs east and west, "as almost useless for the purpose of a route." That shops in it must be approached through side streets and from the rear he considered in reality as no disadvantage, "for lamps are wanted most, not in mere frontages, but in back offices." He thought that there was the less need in the central areas to trouble about keeping them of equal size, since the distances from one sub-station to another were necessarily short. Having secured a sub-station in any one spot, it was easy to estimate, from the accommodation it affords, the extent of the district which it will subserve. He told me that the general plan I had prepared of distributing the alternating current at a pressure of 2,000 volts by mains to transformer sub-stations "could not be improved upon," and agreed entirely in principle with the general plan of distribution as provisionally set out in the maps shown this evening ; and, further, approved generally the size of areas assumed in those maps to be suitable, and that the richest areas so mapped out are the eight areas surrounding the Mansion House (see plan) practical working engineer's experiences. This must be my apology for some diffuseness. Enforced inaction for an engineer is always irksome, especially as he is well able to anticipate the loss and overwork that must follow through dilatoriness of those whose duty it is to make up their minds. Such was my position between July and December, 1891, when valuable time was lost, and heavy and pressing work requiring to be completed by the end of February, 1892, had to be suddenly put in hand. Fortunately, I had foreseen the rush that would come, and had engaged and organised my office and staff so as to be ready to go to work when required, and had also called for and received tenders for the various kinds of articles of plant and materials (several of which had to be specially designed) that the work would require.

The chief difficulties that had to be faced, besides those inseparable from street work in the City, were (1) the time of year (all the fine autumn had been lost), with its wet, mud, and fogs ; (2) the difficulty of readily finding a sufficient number of suitable foremen to take charge of such work ; (3) the inconvenience caused to the public by having 100 yards of footway "up" in nearly 30 different places at one time. My estimates of the cost of the work had been based on the assumption that it would be carried out under own staff, by hiring labour, and by purchasing tools and material, with a reasonable rate of progress. There was no doubt whatever that the intermediary of contractors would be wasteful, even although it was easy to find road and paving contractors in every city of the kingdom. Time being precious, and the Commissioners threatening, my ideal could only be partially carried out. Tenders had therefore to be called for for separate sections of the obligatory streets ; but here the obvious difficuly of price had to be faced. No contractor would quote to lay anything under a City footway without at least 100 per cent. margin, unless he could first take up the surface.

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But this first taking up was not permissible. Tenders under such conditions were obviously objectionable. Then, considering that we wanted several contractors to go to work at once, besides our own gangs, it would have sent the price up a hundred-fold if their tenders were to include the supply of tubes, cases, and material, because they would have been competing for such unprecedented quantities in the same market. There was only one course to follow—namely, (1) to purchase all the materials ourselves; (2) to prepare a specification and schedule of measured prices especially suitable and confined to the kind of work; (3) to pay for the work under measurement.

As regards the first—namely, the material. Wrought-iron tubes, although a considerable stock is to be found amongst makers, are not held in quantities representing hundreds of miles, particularly of the quality of iron, and lap-welded, that we wanted. Our tests of samples were necessarily hasty, but the steam-hammer, though rough, gave us a pretty fair indication of toughness. The very fact of so large a quantity being wanted, instead of enhancing the price, enabled us to do what is called "break the ring," and I believe it is one of the very few cases in which tubes have been sold some 20 per cent. below "ring" prices. All the tubes were treated with Angus Smith compound. As regards the Callender-Webber casing, there was only one maker; but here, again, foresight on behalf of the City lighting had a long time previously provided for special rates in favour of that particular work. At the same time I cannot speak too highly of the great efforts of Mr. Tom Callender at that time to extend his company's means of output, and that at very short notice. I remember that at one time the bitumen we were bound to lay underground in January, 1891, was still, in Christmas week 1890, on board ship in the chops of the Channel.

As regards the second—namely, the specification and schedule (of which a copy may, if the Council permits, be attached)—it is sufficient to state the former consisted of 44 clauses, and that the latter had 55 items, which the tendering contractors were asked to price. But even with these precautions it was felt that, in the case of the most difficult streets, no contractors could be asked to tender at all except they were allowed to charge for whatever they paid out, and then with no obligation to meet all the liabilities for damage to person and property in the most crowded and intricate places in the whole world. To our own engineers and men the work in such places as Cannon-street, Thames-street, Cheapside, Poultry, St. Paul's-churchyard, and around the Bank, etc., was allotted. In the 22 streets in the eastern and central districts which remained to be dealt with at the end of December, the total length of trench to be excavated, and completed with conduits and boxes, was nearly 24,000 yards, of which 9,700 was allotted to the company's gangs. There was only one month to do it in to carry out the conditions of the contracts with the Commissioners. Three contractors at first—afterwards a fourth was added—competed successfully. (Nine firms tendered.) The abstracting of all the tenders showed a variation on the average work between £188, the highest, and £79, the lowest, per 100 yards of work. The highest tender accepted was at the rate of £128 per 100 yards. The same work in the more difficult ground done by the company's gangs cost only £60, including the cost of the plant used by them. The average cost of the materials was about £118 per 100 yards. The actual cost of the work essential to be completed in February was about £59,000. The maximum rate of progress was attained at the beginning of March, 1892, when 1·65 miles of trench was completed in six days' work. An analysis shows that the 4,260 yards by one of the contractors, at £128 + £118 = £246, cost £3,069 more than it would have cost if done by the company's gangs; that the 4,010 and 5,270 yards of the two others respectively cost £2,560 and £1,265, correspondingly, more; giving a total of £6,894. But it may fairly be said that if the contractors had tendered to do the work when the days were fine and long, their prices would have been 5 per cent. less—say, £723. It may be instructive to young engineers present to realise that if the adverse conditions I describe could have been avoided, a saving of about £7,617 on what actually cost over £30,000 would have been effected; and that is exclusive of the advantages in the minor results in the form of better "finish" when the work is done under one's own foremen. If the same work had been carried out at the rates of the highest tenders accepted, it would, including material, have cost £72,000, and if entirely in the way my estimates contemplated, the costs would have been, correspondingly, £40,000; but in neither event, having been begun in December, would it have been all done, as was essential, early in February.

A glance at the map (see Plan No. 20) will show that in the heart of the City there are eight transformer areas designed; and, naturally, as soon as the main thoroughfares were completed, to the completion of conduits in the lesser thoroughfares, streets, and courts of these areas was immediate attention turned. The amount that had to be paid for the work done in the streets by the pioneer contractors (already referred to) was £22,850, which, added to the previously stated amount, came to a total for the main thoroughfares of the eastern and central districts of £81,850. In the whole City there are 92½ miles of frontage, and in the eight special areas there are 22,000 yards. If the average demand for lamps is 2·1 per yard, we get 46,200, or about 6,000 per sub-station area; but, being the richest areas, three lamps per yard, or 8,500 per acre, was estimated. By March, 1892, the cost of the work (not done by contract) could be pretty closely detailed, and the cost of the conduits in portions came to a little over £17,000; giving a total for the completed street work in the main thoroughfares and eight sub-districts of the eastern and central districts, exclusive of conductors (except a small quantity of cable provided under the pioneer contracts, which is included), of £98,850. Of this, the length of trench completed by July, 1892, was 43,000 yards. I have little doubt we shall be told that most of the lighting in those areas is with 16-c.p. lamps. In this respect, I think it is evidently the wrong initiative policy to try to make up a big load before you are ready, in order to make a fair show, instead of keeping it down when first starting by encouraging in every possible way an economy of light by the use of 8-c.p. lamps. It is well known that I have been from the first an advocate of this policy, and I now attribute our measure of permanent success at Chelsea as being large due to it.

It will be readily understood, by a glance at the plan, that the streets bounding the areas having been completed with all the "ways" actually necessary, and that could be put in, the internal cross-streets could be provided with all that the future load could possibly demand for feeders of any size. A more precise idea of the cost of this kind of work laid in streets presenting exceptional difficulty is given below. In an example of the streets in question only eight "ways" could be introduced under the footways on each side—viz.:

	Ways.
In Callender-Webber casing	3
In 1¼in. tubes	4
In 2½in. tubes	1
Total	8

The length of the two sides, taken together, inclusive of the lengths occupied by boxes, is 1,328 yards.

The cost of taking up the surface and temporarily relaying it, at 3s. 9d. per yard lineal, was	£250
Laying conduits and pipes, at 1s. 3½d.	85
Cost of conduits and pipes, at 8s. 6d.	718
Superintendence, storekeeping, cartage, sundries	78
Small stores and blacksmith's work	27
Wear and tear of plant, and contingencies	116
Cost of draw-boxes and service-boxes where actually required	99
Approximate cost of restoring the surface, performed by the Commissioners' contractors, and on their schedule	554
Total	£1,927

Or £1. 9s. yer yard lineal of trench, exclusive of cables.

The equipment of this line with cables of the following sections—namely, two of 0·3 square inch section of copper for low pressure, one of 0·15 square inch section of copper for low pressure, four of 7/16's for high pressure, one of 0·158 square inch (concentric) for high pressure—costs, in addition, £2,037; giving a total cost per yard lineal, inclusive of cables, of very nearly £3.

Including casing used for house services, the total length of ways in bitumen concrete casing laid in the streets and areas named up to July, 1892, was:

In casing unsheathed with iron	4,356 yards
In casing sheathed in iron	148,068 ,,
Total	152,424 ,,

Or over 80 miles. The internal diameter of these varied between 1in. and 2⅜in. The largest proportion of these were of the triangular form (exhibited this evening). The total of 1¼in. wrought-iron tubes laid was 173,000 yards, or 98 miles; of 2½in. wrought-iron tubes, 164,000 yards, or 93 miles. Total of ways of all sorts laid in the City between December, 1891, and July, 1892, 271 miles.

Of the Raworth-Callender-Webber conduit, 212 yards, containing four ways, were laid in Queen-street. This was an experiment, and is an example of paper-lined ways bedded in bitumen and laying in cast-iron troughs, with separate cast-iron joint-pieces, and cast-iron covers bolted down. This latter system, called the "Callender-Raworth-Webber," in which I am joined with those gentlemen by an act of courtesy on their part, is chiefly attractive to me through the possibilities it offered for the use of bare stranded copper. Since then I have brought out, in conjunction with those gentlemen, a further development, being a combination of the two systems above mentioned, called the "Webber-Callender-Raworth" conduit, which I hope may be a step in advance in that much-to-be-desired direction. The durability of the paper has yet to be tested, but of this I have little doubt, if it is thoroughly impermeated. The only drawback is that they cannot be easily bent during laying, and that, as laid in the City, the cast-iron cover has to be cut through with a cold chisel to make a house-service connection. The sheathing of the Callender-Webber cases was mostly made of No. 22 gauge sheet mild steel, which covered the three sides of a triangular, and the four sides of a rectangular case, then secured by studs or cut-in pieces, or 1½in. hoop iron riveted, and the whole painted over with a bitumen solution. Sheathing for these cases was first used in the City work. As is well known, the cost of the casing when it is triangular in section and has three ways of 1¼in. diameter each, is without sheathing 1s. 11d. a yard, which is 7¾d. for each way. The same sheathed costs 2s. 10d., or 11¼d. per yard. Nearly all the 1¼in. wrought-iron tubing laid (generally four tubes under each footway throughout)* cost 9½d. a yard, which was an exceptionally low price for the reason I have already given; this is, against the first cost per yard of ways of the former material, less by 1¾d. per yard. The advantages of the bitumen case, I think, more than counterbalance this: (1) durability; (2) there is less labour in making two bitumen joints than three screw joints (the former are 6ft. apart, the latter 12ft.); (3) the bitumen is more easily cut to lengths and bent than the wrought iron; (4) there is no risk of rust sealing in the cables after they are in the

* Two 1¼in. tubes are destined for the public and two for private arc lighting series cables.

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bitumen ways, as often occurs with iron ways. When you come to compare the 2½in. ways in bitumen and wrought iron, the costs are as follows: in the former each way in a sheathed case costs—with triangular section, three-way, 1s. 9½d. per yard; with rectangular section, three-way, 2s. 1d. per yard.

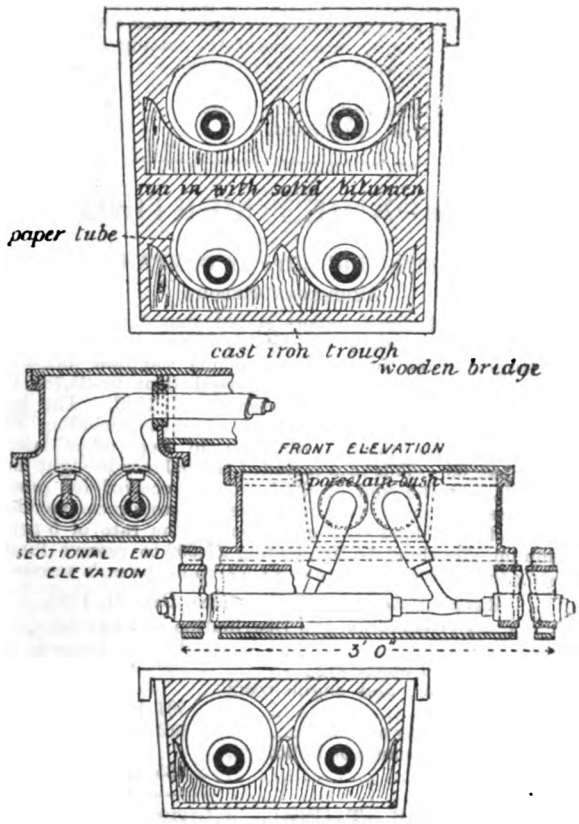

FIG. 21.—Callender-Raworth-Webber Conduit.

This at once compares favourably even with the exceptional low cost of our 2½in. wrought-iron tubing used in the City, which was 2s. 6½d. And when there are six 2½in. ways in a case the cost per way comes out at 1s. 5d. per yard, and a large economy is at once evidenced—increased if the cost of sheathing is avoided. But it must at the same time be noted that where we laid 18 (and mere) 2½in. tubes in the same trench with other conduits—for instance, throughout Thames-street—we might not have found room for three more six-way cases, which in cross-section occupy more space than 18 2½in. tubes. I have not referred to the western district, the contract for the public lighting of which did not require completion before November 5, 1892; but it may be stated that this work alone required 11,614 yards of trench, which, at an average cost of £1. 12s. 1d. per yard, would cost £18,630, exclusive of spare tubes for other purposes.

CONDUCTORS.

As has been stated, the primary alternating-current conductors were concentric 0·154in., with high-class insulation; the high-tension continuous-current conductors were 7/16's concentric, except where the lamps are connected, also with high-class insulation; and the secondary conductors on the three-wire system of various sizes has Callender extra standard type insulation. The two first were drawn into 2½in. and 1¼in. wrought iron tubes respectively. The last was drawn into the three-way Callender-Webber casing, manufactured of three sizes—namely, with 1½in., 2in., and 2⅜in. ways; in each of those the third way is smaller than the other two. The largest were for feeders where necessary, and the two smaller for distributors. In the eight sub-district areas shown on the map (Plan No. 20) it is seen that no consumer's terminals would be more than 100 yards, measured along the main, from a transformer station; consequently, allowing the Board of Trade drop of 4 per cent. above and below the normal, the section of cables first drawn in, the maximum areas of the three conductors, taken together, was ⅜in., and very few feeders except quite short lengths were necessary. It was considered that for a considerable time to come this would comply with a demand of at least three lamps per yard of frontage, the frequency of transforming stations being maintained. The impedance due to retardation was therefore negligible with those sizes. The cable specifications giving the special conditions under which the manufacturers had to tender (of which a copy will be attached to this paper) had some special features—namely: The same results of insulation as were prescribed for the tests at the maker's works were required after each length of cable had been drawn in, in the presence of the maker if he wished it, and before joints were made in it. The maintenance of the insulation, except at joints, was guaranteed by the maker during three years from the date of it being drawn in, and if within that time the dielectric had deteriorated the maker was to replace the cable.

With a view to the company having the advantage of the market rate of the price of copper at the date of the quotation, the contractor was required to state the number of tons of copper, made up in insulated cable, for which he would receive orders at that rate during one year. As it became soon apparent that in each of the eight sub-districts above referred to separate transforming stations might not be obtainable, the question of a distance between them probably greater than had been calculated on required consideration, and the consequent enlargement of the sectional area of the copper in the conductors. The first point that had to be considered was as to the saving that could be effected by the use of hollow-cored cable. With alternating currents having a frequency of 100 there is an inequality of distribution of the current over the cross-section of the cable, and for practical purposes the penetration may be regarded as not exceeding ¼in. from the outside of a cable of stranded copper, and therefore, if above ½in. diameter, the copper in the centre of the strand is not useful. These conditions led to the adoption of the Callender hollow cables for sizes varying between 0·4 and 0·7 of an inch sectional area as the simplest and cheapest form. For instance, such a cable having half a square inch section of copper was made up of 38 No. 10's or 30 No. 9's, in two layers round a hempen core, when the outer diameter of the copper is 1·05in. For anything over ¾ square inch section of copper it was apparent that some form of multiple strand would have to be adopted; but for the supply then contemplated (even with only 600 amperes per square inch density) the maximum of 0·7 of a square inch was sufficient to provide. As regards joints and jointing—that very important matter both in first cost and maintenance—I had examined every form that in 1891 had been before the electrical engineering world, and at that time had no reason to alter the opinion formed from long experience that only when forced to adopt anything else by the construction or dielectric of the cable, could I recommend anything more simple, practical, or durable than the joint made of the same material, and of the same form of covering as the cable itself, and this is applicable to both straight and T joints. As regards the experience gained by the company in the matter of their mains since July, 1892, I shall hope the Institution may have the most instructive information from the engineers who carried on the work after I retired from it. The best qualified is Mr. G. H. Nisbett, who since the autum of 1890 had been my right hand in all matters connected with electrical distribution, and whose intimate knowledge of every part of the City work made it absolutely essential that he should pass from my service to that of the company when I left it. I cannot refrain from also mentioning here two indefatigable assistant engineers on the same duty—namely, Mr. Buck (late R.E.) and Mr. Bates.

(To be continued.)

PHYSICAL SOCIETY.

At a meeting of this society on February 23, Prof. A. W. Rücker, M.A., F.R.S., president, in the chair, Mr. J. W. Kearton was elected a member of the society.

A "**Note on a New Electrical Theorem**" was read by **Mr. T. H. Blakesley, M.A., M.I.C.E.** Two or more dispositions of E.M.F. in any network of conductors which produce at every part of the network the same currents are defined as "equivalent systems." The following theorem is then stated and proved: in any system of conductors possessing seats of E.M.F at any number of points, if any of these sources be moved along the various bars of the conducting system, and where a point of junction is encountered, each becoming a seat of the *same* E.M.F. in *each* of the newly encountered bars, then the disposition at any moment is equivalent to that at any other moment, and therefore to the original disposition. Equivalent systems might also be defined as being such as produce equal expenditure of power in each part. From the above theorem the following propositions are deduced by the author: first, that if any closed surface contains a portion of a network, then an E.M.F. in any bar cutting the surface can be replaced by equal E.M.F. (in opposite directions as regards the surface) in all the other bars cutting the surface, without disturbing the current in any part of the network; second, if two systems of E.M.F. be equivalent, one may be derived from the other.

Prof. C. V. Boys, F.R.S., read a note on the "**Attachment of Quartz Fibres.**" When torsion fibres are required to carry large weights approaching the breaking weight, the ordinary method of attachment by shellac is not always satisfactory, for if the part of the fibre in the cement is twisted or bent, the yielding of the shellac causes uncertainty of zero. To avoid these troubles Prof. Boys has devised and perfected a method of soldering the fibres, full details of which are given in the paper. After selecting a fibre of the right diameter and length, small weights are fixed on the ends by shellac. The end parts are then cleaned by dipping in strong nitric acid, washed, silvered, and electro-coppered. The weights are then cut off and the coppered ends soldered to tags of tinned metal foil, chloride of zinc being used as a flux and its capillarity serving to hold the ends to the tags whilst the latter are heated. The superfluous copper and silver are dissolved off by nitric acid, the tags and solder being protected by beeswax. After washing in boiling water the fibre is ready for use. Melted shellac is used for securing the tags to the torsion-rod and suspended body. Several ingenious details of procedure to avoid capillary difficulties in the cleaning, plating, and washing processes are described in the paper. If fibres are required to conduct electricity, they are silvered and washed after the tags have been soldered on. Such fibres the author considers essential

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for making connection with electrometer needles of the greatest delicacy, for liquid connections are fatal to stability. Methods of rendering fibres visible by smoking with arsenic or magnesium are mentioned in the paper. At the meeting a perfectly circular hole, $\frac{1}{5000}$in. in diameter, made by soldering round a quartz fibre, passing through a hole in a metal plate and then drawing out the fibre, was exhibited under a microscope. **Mr. Inwards** asked if the shellac used to secure the tags was melted or dissolved. **Mr. Blakesley** enquired if silvering fibres did not destroy their perfect elasticity. **Dr. Sumpner** wished to know if any data as to the relative torsional rigidity of silvered and unsilvered fibres had been obtained, and if the electric resistance of silvered fibres had been determined. **Mr. Watson** said silvered fibre had been successfully used in electrometers. As regards their torsion, he had found it differ from day to day, and the resistance varied enormously. In reply to a question, **Prof. Boys** described the exact process of soldering the copper fibre to the tags. As to the torsion of silvered fibres, he would not expect much increase, as the fibre was very thin. He also thought the elasticity would not be destroyed, for silver and gold make very good torsion wires.

THE BOARD OF TRADE AND ELECTRIC TRACTION.

As stated in our last issue, a conference was held last week on the proposed Board of Trade regulations for electric traction at the Board of Trade offices, Sir Courtenay Boyle presiding. We quote the following report from the *Times*:

The Chairman said the regulations they had met to discuss were under clauses which had been inserted in certain Bills, and which would probably be inserted in all Bills as model clauses, in consequence of the action of the joint committee of last year, and would therefore have general application to all instances of traction by continuous currents. Parliament, with a respect for the discretion and decision of the Board of Trade which was very flattering, but which caused a considerable amount of labour, had decided that upon the Board of Trade should devolve the duty of settling the regulations governing the conditions under which traction should be used.

The regulations were then discussed *seriatim*.

Sir Frederick Bramwell, speaking on the regulation which provided that when any part of an electric return was uninsulated it should be connected with the negative terminal of the generator, and the electric company might make one connection to a main for water supply, said that as the regulation stood this could be done simply with the consent of the water company, and he suggested that the consent of the owner of the pipe should be necessary.

Mr. Monier Williams said the gas companies had a similar objection. There was no clause as to damages in the regulations.

Mr. Aspinall thought the water-pipes might be seriously damaged by electrolysis through connection being made with the water-mains.

Sir Courtenay Boyle said they were entitled to see that they were sufficiently protected in these regulations, but they could not ask him to insert the power to award damages, which was a matter for legislation.

Sir Henry Oakley said that, with regard to block signalling on railways, he was advised that it was quite possible that the escape of electricity from some of these high-pressure traction wires might actually reverse the signal intended to be given of "danger" into one of "all right." He thought it should be clearly understood that if the Board of Trade could not provide the protection the railway companies sought they must oppose any and every traction provisional order or Bill.

Sir Courtenay Boyle said the Board of Trade required no pressing on the part of the railway companies to avoid by any possible means any such danger in regard to block signalling.

Mr. Siemens said it really took three manipulations before the block signalling of a railway was interfered with. As long as railway companies had got the earth current, any current, meteorological or otherwise, would interfere with them as much as a current from tram line.

Mr. Langdon replied that meteorological currents were only occasional, but a traction current would be continuous.

Major-General Webber thought it would be very unwise to protect the railway companies in these regulations in regard to their block system, as that might result in their not incurring the small expense which would safeguard them.

Sir Courtenay Boyle said he thought the best plan would be that Major Cardew, the electrical expert attached to the Board of Trade, should go down into Staffordshire and consider the experiments made there by Mr. Dickinson. A further clause should then be drafted, which, if necessary, the objectors might have an opportunity of discussing.

Mr. Morse pointed out that a great many tramway companies had powers of electric traction in previous Bills.

Sir Courtenay Boyle said he was considering this point. He thought the clause should be inserted in every future tramway Bill or provisional order, but he did not think the regulations ought to be scheduled in the clauses.

Mr. Morse.—How would you deal with cases of tramways which already have Bills without these clauses when they come to equip electrically?

Sir Courtenay Boyle.—I think we should recite the clauses in the regulation.

Mr. Morse.—And make the clauses and regulations applicable?

Sir Courtenay Boyle.—No; Parliament must make the clauses applicable.

Mr. Morse.—Then might I ask the Board of Trade whether they will introduce a general Bill which shall make these clauses applicable to Acts already in force where the clauses are not inserted?

Sir Courtenay Boyle said that was a very important question. If there was a sufficient desire on the part of the tramway companies at present having Acts to equip themselves electrically, then there should, he thought, be a general Act putting in these clauses. The Board of Trade would further consider the matter, but until the pressure of the companies was brought to bear on them he thought they would hardly be able to act.

The conference then terminated.

COMPANIES' MEETINGS.

LIVERPOOL ELECTRIC SUPPLY COMPANY, LIMITED.

DIRECTORS' REPORT.

The annual (eleventh) report stated that the directors were again able to announce a satisfactory increase in the number of lamps supplied from the Company's mains, the total number connected on December 31, 1893, being equivalent to 25,784 16-c.p. lamps, as against 20,254 on December 31, 1892. The balance to the credit of the profit and loss account, including £4,851. 19s. 1d. paid for interim dividend in September last, was £12,710. 16s. 6d. This sum included the balance brought forward from 1892, and the sum of £297. 8s. 7d. received for premiums and interest on share account. The directors recommended the payment of a dividend for the half-year at the rate of 5 per cent. per annum, absorbing £5,308, adding £1,000 to reserve fund, and carrying forward the balance of £1,550 to next year's account.

REVENUE ACCOUNT YEAR ENDING DEC. 31, 1893.

A.—To Generation and Distribution of Electricity.

Dr.	£ s. d.	£ s. d.
Coal, carriage and unloading	3,369 8 2	
Oil, waste, water, and engine-room stores	594 16 7	
Wages at generating stations	1,382 6 9	
Repairs and maintenance on buildings, plant, etc.	2,335 17 11	
		7,682 9 5
B.—To Consumers' Lamps.		
Renewals of lamps for consumers		962 0 2
C.—To Rents, Rates, and Taxes.		
Rents payable	121 17 6	
Rates and taxes	338 10 5	
		460 7 11
D.—To Management Expenses.		
Directors' remuneration	496 6 8	
Salaries of managing engineer, secretary, clerks, etc.	1,279 14 5	
Stationery and printing	87 11 7	
General establishment charges	166 14 4	
Auditor of Company	15 15 0	
		2,046 2 0
E.—To Law and Parliamentary Charges.		
Law expenses		49 4 6
F.—To Depreciation.		
Depreciation on buildings	155 10 4	
Depreciation on plant, machinery, etc.	3,674 11 11	
		3,830 2 3
G.—To Renewal Fund.		
Renewal fund		2,000 0 0
H.—To Special Charges.		
Insurance	90 17 4	
Expenses for certification of meters	331 6 6	
		422 3 10
Total expenditure		17,452 10 1
Balance to net revenue account		9,589 10 3
		£27,042 0 4

Cr.	£ s. d.	£ s. d.
Sale of current by meter		24,735 14 8
Rental of meters on consumers' premises	£948 0 5	
Sale of lamps	1,121 1 9	
		2,069 2 2
Rents receivable		237 3 6
		£27,042 0 4

Dr. BALANCE-SHEET, DEC. 31, 1893.	£ s. d.
Capital account	99,000 0 0
Net revenue account	9,589 10 3
Reserve fund account	2,500 0 0
Renewal fund account	5,500 0 0
Depreciation fund account	25,924 15 4
Balance from general funds of the Liverpool Electric Supply Company, Limited	71,708 7 10
	£214,222 13 5

Cr.	£ s. d.
Capital account	214,222 13 5
	£214,222 13 5

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The ordinary general meeting of this Company was held last week in the Sale-room, Exchange Station-buildings, Liverpool, Mr. A. H. Holme presiding.

The **Chairman**, in moving the adoption of the report and statement of accounts, said they proposed to pay what he hoped they would think was a good dividend. They had had a very calm and usual year. There had been the coal strike, which he thought had affected every industry in the country. The exceptionally fine weather in the autumn prevented as much light being used as had been used in previous years. Another unusual thing had been the extension of the city boundaries contemplated by the Corporation. This, he supposed, they might now consider to be almost an accomplished fact. They had made satisfactory arrangements with the Corporation, but he need not enter into them, as the change in the boundaries, although decided upon, would not come into existence until, at the very earliest, the end of this year. The Company had maintained their contract with the public, and had given them good and efficient light. They had had fewer complaints than they had ever had before, and he thought they might now say that the electric light throughout the city was as much to be relied upon as the gas was. They anticipated a large increase in the number of lights, and with that increase they would be able to charge a lower price. The increase in the number of lights had been a very satisfactory one during the past year. Their lights had been increased to the extent of over 26 per cent. There was no doubt they would have a great many more lights in future, and it would be absolutely necessary to extend their premises and provide new boilers at two stations. The rulers of the city did not seem to see their way to use the light for public purposes. He regretted that their streets and all the public buildings belonging to the Corporation were not lighted by electricity; still, he hoped that this would come in time. The expenditure on capital account during the year, including a proportionate charge for general expenses, had been £53,777. They now proposed to spend something like £29,000, and in order to do that they had issued a circular calling up the remaining 10s. per share. They continued to write off a considerable amount for depreciation, and they had put £2,000 to the renewal fund, and they had also increased the reserve fund from £2,500 to £3,500. The total depreciation they had written off since the Company commenced amounted to £26,000, which was neither too little nor too much.

The **Chairman**, in reply to Mr. James Lister, said originally the time fixed for the acquirement of the property by the Corporation was 1900, but a new arrangement had been made in connection with the city boundaries extension scheme which would give the Company an additional 42 years.

The report was seconded and adopted.

On the motion of the **Chairman**, seconded by **Mr. Ybarrando**, a dividend at the rate of 5 per cent. per annum was declared.

Messrs. Samuel H. Holme and J. C. Vaudrey were re-elected directors.

The sum of 750 guineas, free of income tax, was placed at the disposal of the directors as remuneration for their services during the past year, and a vote of thanks to the directors and to the officials of the Company concluded the proceedings.

NOTTING HILL ELECTRIC LIGHTING COMPANY.

Directors: Wm. Crookes, Esq., F.R.S., chairman; A. E. Franklin, Esq.; A. Howden, Esq.; J. T. Jervis, Esq.; F. Radford, Esq.; S. Waters, Esq. Engineer and manager, G. Schultz. Secretary, R. G. Rawkins.

Report of the directors and abstract of accounts at December 31, 1893.

The expenditure on capital account at the date of the balance-sheet amounted to £76,900. 7s. 7d. During the year a further sum of £1,628. 12s. 3d. has been so expended, bringing up the total to £78,528. 19s. 10d. The two principal items of expenditure are £744. 10s. for mains, and £522. 11s. 11d. for purchase of patents and patent rights. The result of the lawsuit between Dr. John Hopkinson and the St. James's and Pall Mall Electric Lighting Company having established the validity of the patent for the three-wire system, the property of the Westinghouse Company, we, in conjunction with the other low-tension electric lighting companies operating in London, agreed to purchase a license for the use of this system throughout our area for the full term of the patent and for any extensions thereof, the proportion paid by this Company amounting to £522. 11s. 11d. This amount has been carried to capital account under the heading above mentioned, and is only a fraction of the additional amount that would have been expended on construction had the three-wire system not been adopted. The revenue account shows a profit of £1,481. 7s. 1d., as compared with a profit of £112. 6s. 1d. in 1892, and a loss of £554. 18s. 6d. in 1891. The amount received from the sale of current shows an increase of £988. 7s. 7d., whilst the expenditure shows a decrease of £552. 14s. 8d. This result has been achieved by the abolition of the City offices, and strict economy in every detail of the work, for which great credit is due to Mr. George Schultz, the engineer and manager. It was only possible to carry these alterations into effect in the middle of the year. It is therefore estimated that a further reduction in management expenses, amounting to £280, will appear in the accounts of 1894. The directors wish to point out that the prime cost of the generation of the current during the second half of the year is lower than that appearing in any of the accounts of other London companies for 1893 hitherto published. On the occasion of the last general meeting, the directors voluntarily surrendered one-half of the fees due to them up to and inclusive of December 31, 1893, amounting to £1,125, and postponed the drawing of the balance until the present report should have been presented and approved by the shareholders. With a view of enabling the Company to start the new year free from all liability, they now surrender £685 of the balance due to them, making £1,810 in all, and accept in full payment for their services since the commencement of the Company's operations a sum of £440. The balance of net profit, after writing off the loss of £347. 16s. 4d. brought forward from the previous year's account, amounts to £1,081. 16s. 1d., and out of this the directors recommend the payment of a full dividend on the 6 per cent. preference shares, requiring a sum of £640. 19s. 4d. The Company has now been placed on a dividend-earning basis. The directors are able to report that the machinery and plant at the central station, as well as the mains, are in excellent condition, and that the supply of current during the year has given general satisfaction to the consumers. The number of houses supplied has increased from 124 to 173; and the number of lights from 9,438 to 12,153. The mains at present run past and opposite to 980 houses which are not yet taking current. The Company suffered no inconvenience through the coal strikes, as a contract had been made and a sufficient store laid down in view of possible contingencies. The Company has been in communication with the Vestry of Kensington with a view to an extension of its area in the district relinquished by the House-to-House Electric Light Company in the north-west portion of the parish, and has expressed its willingness to undertake whatever work may show a reasonable prospect of profit. The directors who retire are Messrs. Alex. Howden and J. T. Jervis, and being eligible they offer themselves for re-election. The shareholders' auditors, Messrs. Deloitte, Dever, Griffiths, and Co., retire, and do not propose to seek re-election, and the shareholders will have at the general meeting to appoint their successors. Messrs. Fox, Sissons, and Co., a member of whose firm was formerly secretary of the Company, offer themselves for the vacant post. The directors would point out that the accounts have also, under the terms of the Act, to be submitted annually to the auditors of the Board of Trade.

REVENUE ACCOUNT, DEC. 31, 1893.

Dr.				£	s.	d.
A.—Generation of Electricity.						
Coal and other fuel, including dues, carriage, etc.	£431	19	9			
Oil, waste, water, and engine-room stores	122	13	6			
Proportion of salaries of engineers, as certified by the engineer-in-charge	128	4	2			
Wages and gratuities at generating station	354	14	6			
Repairs and maintenance as follows: (1) buildings, £112. 7s. 6d.; (2) engines, boilers, £210. 15s. 8d.; (3) dynomos, £30. 8s. 11d.; (4) other machinery, instruments, and tools, £40. 11s. 3d.; (5) accumulators, £88. 13s. 4d.	482	16	8			
				1,520	8	7
B.—Distribution of Electricity.						
Repairs, maintenance, and renewals of mains of all classes, including materials and laying the same	134	8	10			
Proportion of engineers' salaries, as certified by the engineer-in-charge	26	0	0			
				160	8	10
C.—Rents, Rates, and Taxes.						
Rents payable	34	10	0			
Rates and taxes	225	15	11			
				260	5	11
D.—Management Expenses.						
Directors' remuneration—see directors' report—£440.						
Salaries of managing engineers, secretary, accountants, clerks, and messengers	453	12	11			
Stationery and printing	51	2	6			
General establishment charges	73	3	9			
Auditors of Company	15	15	0			
Auditor appointed by the Board of Trade under the provisions of the order	24	18	0			
				618	12	2
E.—Law and Parliamentary Charges.						
Law expenses				13	13	0
F.—Special Charges.						
Insurances	33	17	0			
Subscription to the Electrical Association	25	0	0			
				58	17	0
G.—Connecting Installations, and Sundry Stores				216	6	2
Balance carried to net revenue account				1,481	7	1
				£4,329	18	9

Cr.	£	s.	d.
Sale of current per meter, after providing for bad debts	3,507	4	8
Rental of meters and other apparatus on consumers' premises	182	4	6
Connecting installations, sale of stores, etc.	375	10	4
Rents receivable	262	9	3
Transfer fees	2	10	0
	£4,329	18	9

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Dr. GENERAL BALANCE-SHEET, DEC. 31, 1893.	£	s.	d.
Capital account—amount received	78,480	0	0
Sundry tradesmen and others due on contracts for fuel, stores, etc , to December 31, 1893	232	4	11
Sundry creditors	926	19	3
Net revenue account—balance at credit thereof	1,081	16	1
	£80,721	0	3

Cr.	£	s.	d.
Capital account—amount expended for works, including preliminary expenses	78,528	19	10
Sundry debtors for current supplied, etc., to December 31, 1893	1,434	10	4
Other debtors	30	2	0
Stores on hand at December 31, 1893:			
Lamps £7 12 0			
Meters and switches 218 10 8			
Coal 6 2 6			
General 108 6 11			
	340	11	1
Stock (movable plant and tools)	345	8	3
Cash at bankers—Parr's Banking Company and the Alliance Bank, Limited, Notting Hill 37 4 4			
Cash in hand 4 4 5			
	41	8	9
	£80,721	0	3

The annual meeting of the Company was held on Tuesday afternoon at the offices of the Company, Bulmer-place, Notting Hill-gate, Mr. William Crookes, F.R.S., occupying the chair.

The **Chairman**, in moving the adoption of the report, said that the result of the past year's working had quite reached their expectations. Referring to the accounts, as regarded No. 1 (statement of share capital), a certain portion of the capital expended in preliminary expenses was unremunerative, and not balanced by any visible asset, and this was represented by £5,500 founders' shares, leaving the rest of the capital practically represented by the visible assets of the Company. Respecting No. 2 (loan capital), the Company was free from any mortgage or debenture debt. In No. 3 (capital account), the item of £744 had been spent on making small extensions in mains to connect up houses. In most cases a satisfactory return on the capital outlay had been guaranteed. The item for patents was explained in the report, and they had a license to use the three-wire system in their area. The extra cost of construction would otherwise have been £5,000, or about 10 times as much. In No. 4 (revenue account) the cost of coal was the same as in the preceding year, the coal strike not having affected them owing to the foresight of the engineer, Mr. G. Schultz. The consumption of coal had been saved by alterations in machinery, and further economies therein would take place. It was not proposed to raise the engineer's salary of £250, but to remunerate him more in accordance with his value. The directors had decided to give him 5 per cent. on the money expended in dividends. Rates and taxes were very high, being 3s. in the pound on the net revenue owing to the high valuation on works and mains. The directors considered it should not be over one-tenth of the gross income. The directors had not drawn their full fees, and had agreed to take £440 in full discharge of arrears, amounting altogether to £2,125. The law expenses last year were only £13. 13s. The profit on the year's working amounted to £1,481, which compared most favourably with that of the previous year, when a loss of £137 would have resulted but for a fee of £250 from the New Telephone Company. The year before the actual loss was £554. The balance of profit on No. 5 (net revenue account) was £1,081, out of which was recommended a full dividend on the preference shares for the last year, being the first dividend paid. The proportion of increase of revenue was about 10 per cent. less than the increase in the number of lamps. It was estimated that, without allowing for any increase on the number of lamps at the end of last year, a net revenue of £2,500 would be obtainable this year, allowing 2½ dividend on ordinary shares at the next meeting; but, of course, further applications for light had since been received. No money had been passed to No. 7 (depreciation fund), but the directors had expended out of revenue and charged against the year's expenses £617 (equal to about 1 per cent. dividend on the ordinary shares) in renewals and reconstruction. The expiration of the lamp patent would be an inducement to householders to take current. At present their mains passed 980 houses not taking any. The number of lamps on their system had increased by 2,715 during the year. The average lamp earnings showed a tendency to sink, being only 6s. 6d. per lamp. This was probably due to the exceptional absence of fog. The Company's sheer cost per unit was lower than that shown in the accounts for 1893 of any other London company. This was the more remarkable inasmuch as the Company's output was the smallest. Now that they had turned the corner the future success of the Company was assured. Mr. Crookes then moved the adoption of the report and the payment of a full dividend on the preference shares.

Mr. Alexander Howden seconded this, and the motion was carried unanimously.

The retiring directors, Mr. Alexander Howden and Mr. J. T. Jervis, were re-elected, and Messrs. Fox, Sissons, and Co. were appointed auditors, at a fee of 30 guineas, in place of Messrs. Deloitte, Dever, Griffiths, and Co., who retired.

In reply to a question, the **Chairman** said that the Company had offered the Vestry to light the streets at cost price, but this had not been accepted. The directors, however, hoped that something might yet be done in the matter.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY.

The thirtieth ordinary general meeting of this Company was held on Tuesday at the offices, Old Broad-street, Admiral Sir George H. Richards in the chair.

The **Chairman**, after alluding to the deaths of Sir G. Elliott and Captain Halpin, said that the Company had done a very good half-year's work, both as regarded cable manufacturing, the laying of cables, and other business generally. They had laid in various parts of the world cables to a distance of nearly 4,000 miles, and that very successfully. He did not see why he need allude to the causes which had produced the commercial depression of late, since the Company had been free from it. He then moved: "That the report and accounts of the directors to December, 31, 1893, submitted to the meeting be and are hereby received and adopted, and that a dividend of 36s. per share, in addition to the 12s. per share interest or interim dividend paid to June 30, 1893, be paid upon all shares of the Company for the year ending December 31, 1893, and that such dividend be paid free of income tax."

Mr. Philip Rawson, J.P., seconded the resolution, which, after some discussion, was adopted.

WATERLOO AND CITY RAILWAY COMPANY.

The first ordinary meeting of this Company was held last week at the offices, Waterloo Station, under the presidency of Mr. Wyndham Spencer Portal.

The **Chairman** said that the number of shareholders on the register was 38. His first duty was to lay on the table the Act of Incorporation empowering the Company to construct an underground railway from Waterloo to the Mansion House. This being the first meeting, there were no accounts to be submitted; but he might mention that everything was in trim for the operations of the future. As he had stated at the half-yearly meeting of the London and South-Western Railway Company, that company was deeply interested in the undertaking, which they regarded as of great value to them. It was to be a line for passengers only. It was estimated that it would be completed within two years and a half, as they anticipated no serious difficulty. In conclusion, he congratulated Mr. Scotter as the author of the scheme, as the South-Western Company had been wishing for such a line for the past 30 years.

Resolutions were adopted expressing concurrence in the issue of share capital to the amount of £500,000, with the usual borrowing powers, and in an agreement with the London and South-Western Company for the working and maintenance of the line, and for the guarantee by that company of interest on the capital at the rate of 3 per cent. in perpetuity, and two-thirds of any surplus earnings after payment of that amount, the remaining third to go to the working company.

COMPANIES' REPORTS.

CAMBRIDGE ELECTRIC SUPPLY COMPANY, LIMITED.

Directors: Rev. G. B. Finch, chairman; Hon. C. A. Parsons, managing director; Sir B. C. Browne, D. Munsey, Esq., John B. Simpson, Esq., G. Whitmore, Esq. John H. Barker, general manager and secretary.

Report of the directors to be presented to the second annual general meeting to be held at the Company's offices at Cambridge on Tuesday, March 6, at noon.

Your directors have pleasure in reporting that the prospects of the Company are satisfactory. During the last 12 months lamps equivalent to about 6,000 lamps of 10 c.p. have been connected to the Company's mains, making a total at the present time equal to 8,000 lamps of 10 c.p., and there is every prospect that the number will be largely increased during the present year. The plant during the last three months has been fairly loaded, and has worked to the satisfaction of the directors, but owing to the coal strike in the autumn a considerably increased price had to be paid for fuel. It seemed to your directors that it would be inexpedient to commence a profit and loss account in respect of supply of energy, with only a small portion of the machinery at work, and they have therefore deemed it advisable to carry all receipts and expenditure under this head up to June 30 last to capital account. The Company has made a profit of £268 to December 31 last, and it is anticipated that with the additional lamps lately connected and those which will shortly be connected, your directors will be able at the next annual meeting to advise the payment of a substantial dividend for the current year. Your directors have thought it necessary to apply to the Local Authority for their sanction to the temporary suspension of the supply of current, between the hours of 2 a.m. and 5 p.m. in summer, and 2 a m. and 6 a.m in winter. A supply during these hours would involve the shareholders in heavy additional expenditure at the present early stage of the Company's operations, with-

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out any corresponding benefit to the general public. Your directors, however, hope that the applications for current will shortly be sufficient to justify them in making the supply continuous, and it will be their endeavour to effect this at the earliest opportunity. The Rev. G. B. Finch and Mr. J. B. Simpson retire by rotation; the latter is eligible and offers himself for re-election. The directors also recommend the election of Dr. P. W. Latham and Mr. W. C. Hall.

Dr. Balance-sheet, Dec. 31, 1893.	£	s.	d.
Capital—5,000 shares at £10 each	50,000	0	0
2,775 shares issued, £8 called up	22,200	0	0
Debentures, £7,000 at 5 per cent.	7,000	0	0
	29,200	0	0
Creditors	1,543	3	8
Profit and loss account—profit for year ending December 31, 1893	268	10	11
	£31,011	14	7

Cr.	£	s.	d.
Amount expended to date on land, buildings, plant, pipes, cables, meters, transformers, electrical instruments, etc.	26,609	7	1
Office furniture	119	17	4
Stock of stores and fittings	54	19	2
Cost of provisional order	1,005	0	0
Preliminary expenses	1,727	14	8
Debtors	1,468	15	7
Cash in hand	26	0	9
	£31,011	14	7

Profit and Loss Account, Half-year ending Dec. 31, 1893.

Dr. *Electric Energy Account.*	£	s.	d.
Wages, salaries, rents, rates, and taxes	405	0	7
Stationery and office expenses	36	15	8
Stores, fuel, water, etc.	588	8	2
Repairs and renewals	43	13	6
Balance carried down	272	6	10
	£1,346	4	9

Cr.	£	s.	d.
Electric energy supplied	1,267	2	5
Meter rents	79	2	4
	£1,346	4	9

Dr. *Installation Account.*	£	s.	d.
Wages, cables, fittings, etc.	2,506	0	11
Balance carried down	147	9	5
	£2,653	10	4

Cr.	£	s.	d.
Installations, etc., fitted	2,653	10	4
	£2,653	10	4

Dr.	£	s.	d.
Interest on debentures	151	5	4
Balance carried to balance-sheet	268	10	11
	£419	16	3

Cr.	£	s.	d.
Balance brought down, electric energy	272	6	10
,, ,, ,, installation	147	9	5
	£419	16	3

YORKSHIRE HOUSE-TO-HOUSE ELECTRICITY COMPANY, LIMITED.

Directors: Grosvenor Talbot, Southfield, Burley, Leeds, chairman; George Henry Crowther, civil engineer, Huddersfield; Robert William Eddison (John Fowler and Co., Limited, Leeds), engineer, Leeds; Robert Hudson, engineer, Gildersome Foundry, near Leeds; Samuel Ingham (Illingworth, Ingham, and Co.), timber merchant, Leeds; Arthur Greenhow Lupton (Wm. Lupton and Co.), cloth manufacturer, Leeds; John Thomas Pearson, The Hall, Melmerby, S.O., Yorkshire. Consulting electrical engineer: Robert Hammond, M.I.E.E., 117, Bishopsgate, London, E.C. Secretary: Wm. T. Green.

Report of the directors to be presented to the ordinary general meeting of the Company, to be held at the offices of the Company, Whitehall-road, Leeds, on Tuesday, March 6, 1894, at 2.30 p.m.

The directors submit herewith a statement of the income and expenditure for the past year, and the balance-sheet showing the assets and liabilities of the Company made up to December 31 last. The net profit amounts to £1,155. 6s. 1d., out of which the directors recommend that £1,000 be appropriated in reduction of the preliminary expenses account, carrying forward the balance of £155. 6s. 1d. In view of the short period during which the plant has been in use, and the fact that in respect to a large portion thereof the contractors' guarantees of maintenance had not expired on December 31, the directors do not consider it necessary at the present time to make any provision for depreciation. The absence of such necessity renders it possible to write off the above-named comparatively large sum from preliminary expenses.

The Company's permanent plant has only been at work since May 1 last, a period comprising all the summer and only half the winter months. The accompanying accounts therefore practically show results obtained during the least favourable portion of the year. The effect of the dispute in the coal trade was to add considerably to the cost of production, although the precaution was taken of securing a large stock of coal before the stoppage. Under all the circumstances the directors think the accounts now presented may be regarded as satisfactory, and they are glad to report that the supply of electricity has been maintained in such a manner as in their opinion to reflect credit upon the makers of the plant, and upon the works manager (Mr. Harold Dickinson) and the rest of the Company's staff. Almost immediately after the starting of the works it was found advisable to order an additional 200-i.h.p. engine and dynamo, which have been in satisfactory operation since the month of November. In order to obtain necessary capital, the directors invited the existing shareholders to take up the balance (2,634 shares) remaining unallotted of the first issue of 10,000 ordinary shares, and the whole of the shares have been applied for and allotted. In view of the expected early increase of demand, a further extension of the Company's works has been resolved upon, and tenders have been accepted for additional machinery of a capacity of 800 i.h.p., and for the necessary additions to the buildings, the whole to be completed and ready for next winter's lighting. The capacity of the works will thus be increased from 700 i.h.p. to 1,500 i.h.p. This extension will necessitate a small increase of capital, in addition to the amount now uncalled on part of the Company's shares, and the directors will consider how this additional capital can be raised most advantageously for the shareholders. The directors have announced that on April 1 next the standard price of electricity will be reduced from 8d. to 7d. per Board of Trade unit, subject to a scale of discounts, etc. The retiring directors, Mr. George Henry Crowther and Mr. Arthur Greenhow Lupton, being eligible, offer themselves for re-election. Mr. John Gordon, jun., offers himself for re-election as auditor.

Revenue Account Year ending Dec. 31, 1893.

Dr.	£	s.	d.
Coal, including carriage, unloading, storing, and all expenses of placing the same on the works	667	17	4
Oil, waste, water, and engine-room stores	145	9	2
Salaries and wages of engineers and workmen	890	17	10
Repairs and maintenance	117	14	9
Erection, hire, and removal of temporary engine	73	0	0
Rates and taxes	114	3	2
Directors' remuneration	333	6	8
Salaries of secretary and clerks, stationery and printing, law expenses, and general establishment charges	337	10	5
Insurance	26	5	1
Total expenditure	2,706	4	5
Balance carried to net revenue account	1,294	17	10
	£4,001	2	3

Cr.	£	s.	d.
Sale of current, rental of meters and other apparatus, etc.	3,771	7	4
Rents receivable	142	0	3
Transfer fees	3	2	6
Students' instruction	84	12	2
	£4,001	2	3

Dr. Net Revenue Account.	£	s.	d.
Interest on loan	240	0	0
Balance carried down	1,155	6	1
	£1,395	6	1
Amount written off preliminary expenses	1,000	0	0
Amount carried to next account	155	6	1
	£1,155	6	1

Cr.	£	s.	d.
Balance from last account	11	11	3
Balance brought from revenue account £1,294 17 10			
Interest on deposit with Leeds Corporation 20 0 0			
Bank interest 68 17 0			
	1,383	14	10
	£1,395	6	1
Balance—proposed to be appropriated as shown *per contra*	1,155	6	1
	£1,155	6	1

General Balance-sheet.

Dr. Capital and Liabilities.	£	s.	d.
Capital account	45,270	10	0
Sundry tradesmen and others, due on construction of plant and machinery, fuel, stores, etc., to December 31, 1893	2,664	12	5
Sundry creditors on open accounts	1,178	8	10
Net revenue account—balance at credit thereof	1,155	6	1
	£50,268	17	4

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Cr. Property and Assets.	£	s.	d.
Capital account—amount expended for works	42,154	10	6
Stores on hand at December 31, 1893—coal, £17. 6s.; oils, waste, etc., £38. 8s. 10d.; general, £107. 3s. 6d.	162	18	4
Sundry debtors for amounts paid on account of contracts in course of completion	1,188	10	0
Preliminary expenses, including all expenses of management during construction of works	2,185	12	2
Sundry debtors for current supplied to December 31, 1893	2,651	1	3
Other debtors	22	2	6
Deposit with Leeds Corporation and interest	1,010	0	0
Cash at bankers	882	14	8
Cash in hand	11	7	11
	£50,268	17	4

BUSINESS NOTES.

Western and Brazilian Telegraph Company.—The receipts for the week ended February 23 were £3,181.

Liverpool Overhead Railway.—The traffic receipts of this railway for the week ending 25th ult. amounted to £616.

Liverpool.—The committee of the Junior Reform Club intend to introduce the electric light, at an estimated cost of installation of £1,000.

Direct Spanish Telegraph Company.—The Board recommends a dividend at the rate of 4 per cent. per annum for the half-year ended December 31.

St. Pancras.—The St. Pancras Vestry invite, by the 5th inst., tenders for Lancashire boilers, economiser, feed pumps, engines, dynamos, condensing plant, etc.

Finchley.—The School Board have instructed the clerk to write to the Education Department enquiring if a loan for the electric lighting of the schools would be sanctioned.

Dividend Warrants.—The dividend warrants on all preference shares of the City of London Electric Lighting Company, Limited, were posted to the shareholders on the 22nd ult.

Electric Time Distributing and Clock Company, Limited.—This Company has been registered, with a capital of £5,000 in £1 shares, to acquire and turn to account certain patents relating to improvements in electric clocks.

Chelsea.—The Chelsea Vestry have decided to light the town hall by electricity. Estimates have been obtained from 13 firms, varying from £225 to £500. Mr. Morgan Williams, of 39, Victoria-street, S.W., is to superintend the work.

Keighley.—The Town Council have instructed the town clerk to give the necessary notice and make application to the Board of Trade for a provisional order empowering the Corporation to lay down an installation and supply the electric light.

Bury.—The Technical School Committee of the Corporation of Bury invite tenders for the supply of electric light fittings, including switchboards, lamps, wiring, etc., for lighting the technical school. Tenders to be sent to the borough engineer by the 10th inst.

Harrogate.—The Corporation of Harrogate invite, by the 14th inst., tenders for the following plant in connection with the proposed electricity works: refuse sorting and drying plant, with accessories, steam-boilers and accessories, steam and exhaust pipes, transformers and accessories, distribution mains.

City and South London Railway.—The receipts of the Company for the week ending February 25 were £945, against £943 for the same period last year, or an increase of £2. The total receipts for the first half-year of 1894 show a decrease of £133 compared with those for the corresponding period of 1893.

Kingston-on-Thames.—The proceedings of the Electric Lighting Committee presented to the Town Council last week, recommended the acceptance of the tender of Messrs. New and Mayne for fittings for electric lighting in a portion of the market under the Town Hall for £19. 2s. The minutes of the committee were adopted.

Norwich.—At a meeting last week of the Town Council, Mr. Wild moved the acceptance of the tender of Messrs. A. Pank and Son, of Norwich, to provide and fix fittings for lighting by electricity the Guildhall, municipal, and sanitary offices for £290. 17s. This having been seconded by Mr. Dakin, was after some discussion adopted.

Dissolution of Partnership.—The firm of Charlesworth, Hall, and Co., of Oldham, has been dissolved. Mr. Joseph Platt Hall has purchased Mr. Charlesworth's interest in the property and assets of the company, and will carry on business as electrical engineer at Blackriding Ironworks, Oldham, under the style of J. P. Hall and Co.

Blackpool Tower Buildings.—The contract for the electric lighting of the Blackpool Tower buildings has been let to Messrs. Verity and Sons and Messrs. Siemens, the amount of their estimate being £6,092. 10s. The contract for plastering at the same buildings has been let to Messrs. T. and S. Wardle, of Manchester, their estimate being £2,260.

Leeds.—The directors of the Yorkshire House-to-House Electricity Company, Limited, have decided to let the contracts for the extension of the electricity works as follows: to Messrs. William Nicholson and Son, for the buildings; and to Messrs. Hick, Hargreaves, and Co., Limited, and Messrs. John Fowler and Co. (Leeds), Limited, for the plant.

Acton.—The Works Committee to the Local Board last week reported that, after making some slight alterations, they had instructed the clerk to return to Mr. Medhurst the agreement as to the electric lighting of the district. The committee added that if Mr. Medhurst accepted these alterations, the conditions of lease and the schedule could be reconsidered.

Wigan.—At a meeting of the Gas Committee last week, it was resolved that the committee proceed with the erection of electric lighting works, and that in the event of the resolution meeting with the approval of the Council a meeting of the committee be called for Friday, March 9, to consider the question of the appointment of an electrical engineer to advise the committee.

Water-Tube Boilers.—Messrs. R. Hornsby and Sons, Limited, of Spittlegate Ironworks, Grantham, are manufacturing a large double-furnace water-tube boiler for the Whitehead Torpedo Company, at Weymouth, being the third order given by them for this type of boiler. We understand from the purchasers that the economy of fuel in the working of these boilers is quite beyond their expectations.

Aberdeen.—Mr. Wm. Smith, harbour engineer, is preparing a modified scheme on the lines of Mr. Copland's proposal for the improvement of Regent Bridge. It is now proposed to have a travelling bridge in place of a swinging bridge, the roadway rising and falling as the bridge opens and closes. The motive power for the opening and shutting of the bridge will be electricity; and the estimated cost is £6,000.

Mansion-Lighting at Ilkley.—Messrs. Andrews and Preece, of Bradford, have secured the contract for the electric light installation for the mansion now being erected at Ilkley by Mr. W. Smith. The motive power will be supplied from one of Messrs. Gilkes's vortex turbines. The specification has been prepared by and the work is in charge of Mr. Edwin Blakey, M.I.E.E., consulting engineer, of Tanfield-chambers, Bradford.

The Maxim-Nordenfelt Company.—Admiral of the Fleet Sir Edmund Commerell, chairman of the Maxim-Nordenfelt Guns and Ammunition Company, Limited, mentioned last week that the company had taken up electricity as a branch, and that they found that their workmen could do this sort of work quite as well as they could make Maxim guns. They considered that electricity offered an excellent field for employment in the future.

Electric Cranes.—Messrs. J. G. Statter and Co., Limited, of Princes-mansions, 68, Victoria-street, S.W., inform us that, following the completion of the electric cranes erected by them for the Southampton Harbour Board and those for the London and India Docks Joint Committee, they have received an order from the South-Western Railway Company of Russia for three electric cranes and generating station for the harbour at Odessa.

Islington.—The vestry clerk read a communication last week from the London County Council stating that they were prepared to grant a loan of £9,000 for the purpose of purchasing a site for an electric lighting station, at the rate of £3. 10s per cent. per annum, calculated quarterly by equal half-yearly instalments of principal and interest combined for 55 years, the Vestry to pay the cost of the loan. The letter was referred to the Electric Lighting Committee.

Edinburgh.—The Corporation of Edinburgh invite tenders, by the 17th inst., for the following work in connection with the electric lighting of the city: Contract No. 5, construction of concrete culverts and laying of stoneware and iron pipes and casings; No. 6, supply of cast-iron pipes, casings, and road service boxes; No. 7, supply of stoneware casings and insulators; No. 8, supply of copper strip; No. 9, supply of armoured and unarmoured insulated cable.

Bournemouth.—At a meeting of the Town Council last week the Lighting Committee reported a letter from the Town's Interest Association, asking whether the time had not arrived for lighting the borough with electricity. The committee recommended that a reply be given to the effect that the Council were not prepared to consider the question at present. The report was adopted. The report of Major Cardew with reference to the recent accident was received and referred to the Lighting Committee.

Newark.—At a meeting last week of the Sanitary Authority the Electric Lighting Committee reported that they had had before them an application from Mr. Norledge, solicitor, asking their sanction to a company obtaining a provisional order to supply the town with the electric light, and they had decided to leave the question open for the opinion of the Authority. The Mayor proposed that the application be not granted. Mr. Shepherd seconded the resolution, which was carried.

The Effect of Lightning upon Trees.—With reference to the note on this subject in our last issue, Messrs. S. Burnley and Son, of 121, Coldharbour-lane, Denmark Hill, S.E., write to us as follows: "Last March a cherry tree was supported by being fastened round the centre with a stout, solid iron wire to a poplar tree about 30ft. apart, and during the summer gave plenty of fruit, but in September was struck by lightning, supposed by the wire from the poplar tree. The poplar tree is not affected, but the cherry tree is quite dead, as can be seen."

New Installation at Liverpool.—Messrs. Bennett and Druce, 44, Fishergate, Preston, have been entrusted by Messrs. Frisby, Dyke, and Co., of Liverpool, with the complete lighting of their premises by electricity. The plant will consist of an "Otto" gas-engine, giving 22 h.p. on the brake, a compound-wound dynamo, and about 250 lamps distributed over the shop and premises to the entire exclusion of gas. Provision is to be made

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for taking current from the supply company's mains in case a few lights are required during the daytime.

Church-Lighting.—Mr. C. W. Watling, of 110, New-road, Dearnley, Rochdale, informs us that an installation of the electric light has been made in the new church of St. Andrew, Dearnley, a suburb of Rochdale. The work of installing the light has been carried out by Mr. James Wilcock, electrical engineer, of Littleborough, near Manchester, to the satisfaction of the Building Committee. The church is lighted by 60 100-volt incandescent lamps, the dynamo being driven by a 4-h.p. nominal Crossley gas-engine.

Lighting of Sir Thomas Lucas's House.—This work is now nearing completion, and the contractors, Messrs. Drake and Gorham, have dealt in a satisfactory manner with the difficulties which presented themselves at every turn. Sir Thomas was naturally desirous that the splendid decorations should not be interfered with in any way, and before the contract was given full enquiries were made as to how similar work had been dealt with, which had proved eminently satisfactory. Another source of difficulty was the solid construction of the building, and no cutting away was allowed, a positive assurance being given to Sir Thomas Lucas to that effect. There are 370 lights.

Electrically-Lighted Omnibuses.—The Omnibus and Tramcar Electric Lighting Company have acquired the license for the patent that has been tested for two years on the Paris, Lyons, and Mediterranean Railway, and the Liège and Maestricht Railway with satisfactory results. For the new battery invented by Messrs. Theryc and Oblasser it is claimed that the problem of lighting road vehicles has been solved. On Saturday, at the offices of the Omnibus and Tramcar Electric Lighting Company, 18, Eldon-street, E.C., there was a demonstration of the capabilities of the new system. It is proposed that each omnibus should carry a lamp provided with a special bullseye reflector, and yielding light equal to that of 2½ candles. A battery weighing 30lb. will, it is said, furnish a light of 2½ c.p. for 45 to 55 hours.

A Petroleum Question.—The India Rubber, Gutta Percha, and Telegraph Company, of Silvertown, were last week summoned for keeping at their Birmingham branch a solution which, within the meaning of the Act, was petroleum, without obtaining a license. Over 1,000 cans of liquid seized were found to contain a solution of rubber and naphtha, the proportion of naphtha being 84·8 per cent. The solution gave off vapour of 58deg. F., being less than 78deg., as required by the Act. It was argued, in defence, that the solution was not petroleum in the meaning of the Act, and that the Act was intended to apply to fine petroleum, and not to admixture with other substances for commercial purposes. It was extensively used in the manufacture of tyres and bicycles, and defendants were not aware that they were under any legal obligation. A fine of 40s. and costs was imposed.

Electric Lighting of Paperworks.—The extensions which have from time to time been carried out at the Ulverston Paperworks by Messrs. S. Pollitt and Co. have been succeeded by the substitution of the electric light for gas, and this system of illumination was last week successfully inaugurated. The installation, which was contracted for and completed by Messrs. W. R. Thornton and Son, electrical engineers, of Duke-street, Barrow, under the personal management of the junior partner of the firm, consists of a vertical steam-engine driving a dynamo by means of a leather link belt, and the total number of lights provided for is equal to 500 lamps of 8 c.p. The engine is of about 30 i.h.p., and it runs at 190 revolutions per minute. The dynamo is compound wound. The distributing switchboard divides the installation into eight separate circuits, comprising offices, machine-room, sorting-room, beating-room, engines, and boilers, rag-boiler, joiners' shop, and bagmaking-room.

Portsmouth.—Mr. E. Manville has written as follows to Mr. George Ellis, Landguard, Southsea: "Referring to the statements that I understand have been published in the Portsmouth papers with relation to the accident to a horse at Bournemouth, I wish to point out to you that it is impossible such an accident could happen at Portsmouth through the electric light mains there. According to Major Cardew's report to the Board of Trade, the high-tension electric light mains at Bournemouth consisted of two separate cables, both of which were insulated, or rather attempted to be insulated, from the earth. In your case the high-tension conductors consist of two concentric conductors, one without the other, and the outer one is placed in good connection with the earth. It therefore follows that it is impossible that anything can come in contact with the inner or live conductor. In addition, those precautions which Major Cardew stated would have prevented any accident occurring at Bournemouth had they been adopted there, have been already provided for in your system."

Keswick.—The annual report of the Keswick Electric Light Company has just been issued, in which the directors state their inability to recommend a dividend, but are obliged to declare a loss on the past year's business of £69. 5s. 7d. The use of steam instead of water (which the directors have been unable to avoid) is of itself sufficient to account for loss of profit, but the directors have now confident expectations of being able very soon to use the whole water power of the river, without which success is impossible. The trade of the past year shows an increase of 51 lamps, representing £66. 9s. 3d. in receipts. There appears to be a decided disposition in the neighbourhood for people to avail themselves of the light, but as the output is restricted the directors cannot push business as they would like to do. Were ample machinery supplied for procuring the current, they feel confident of a fairly satisfactory result. To obtain this result it will be necessary to procure more capital. Considerable additions to and alterations in plant, wiring, etc., will be necessary to work an increased and remunerative trade, which cannot be expected from the present small station. The directors therefore trust that when their plans for enlargement of the station have been prepared and laid before the shareholders, a ready response will be made, and the necessary additional capital subscribed. The directors have thought it necessary in the interests of the company to procure from a professional electrical engineer a full report upon the station and works, and suggestions as to the alterations and additions required to make the undertaking a success.

The Windsor Electric Lighting Difficulty.—At the Windsor Police Court last week Mr. A. E. Farrow, engineer to Messrs. Roger Dawson, Limited, of London and Windsor, was charged with having broken up the High-street without having first obtained the consent of the Town Council, acting as the urban sanitary authority for New Windsor, as required by the Public Health Act, 1875, sec. 149. Mr. G. H. Long, town clerk, appeared for the Sanitary Authority. The defendant was unrepresented. It transpired that at half-past ten on the night of January 2, the workmen, acting under instructions from the defendant cut a trench 39ft. to 40ft. long and 9in. wide across the High-street, in order to lay down electric lighting wires. The superficial area disturbed was put by the borough surveyor at 46ft. 3in. The defendant pleaded guilty to having instructed the workmen to make this trench, and he explained that he had not asked for permission because he had been told by Mr. Sevenoaks that he would not be likely to get it, and he was advised to take up the street without permission, as was done on a former occasion, when wires were laid across Peascod-street to a Mr. Badger's shop. The Town Clerk stated that permission for such work, when properly asked for, was never refused. He also said that the Town Council had given him no instructions to proceed in Badger's case. The chairman (Mr. G. H. Peters) observed that it could never be tolerated that anybody could come into Windsor and pull up the roads and paths, and set the authorities at defiance. The Bench did not desire to deal harshly with the defendant, but he would have to pay a fine of £2, and a penalty of 3d. per square foot, and costs £1, making altogether £3. 10s. The money was paid at once. The statute provides a penalty not exceeding £5, and a further penalty not exceeding 5s. per square foot.

Hanley Electricity Works.—The Town Council obtained a provisional order in 1891, and in September, 1892, the Council accepted the tender, amounting to £15,760, of the Brush Electrical Engineering Company for the boilers, engines, dynamos, mains, and sub-station transformers requisite for dealing with the compulsory area lighting, both public and private, in its first stages. The Board of Trade approved of the system adopted for the supply of electrical energy, subject to the regulations and conditions for securing the safety of the public, and for ensuring a proper and efficient supply imposed upon the undertakers by the provisional order. The system adopted is the high-pressure alternating current method, with transformers at sub-stations, from which low-pressure distributing mains are to be laid to consumers' premises. The sanction of the Board of Trade to the scheme having been obtained, the Local Government Board, after enquiry, consented to the Council borrowing the sum of £21,000, repayable in 25 years, for the purposes of the order. A contract was soon afterwards entered into with Mr. C. Cornes for the erection of the requisite buildings at the generating station. The electric works are situated on land belonging to the Park estate, and near to Messrs. Hampton's brickworks, on the south side of Clifford-street. The present plant consists of two 100-i.h.p. vertical compound engines, each driving by means of ropes a 50-kilowatt alternator; two 200-i.h.p. engines of the same kind, each driving a 100-kilowatt alternator. A dynamo capable of producing the exciting continuous current required for all the alternators will be driven by the power derived from each of the first-named engines. Space remains for the erection of another 200-h.p. engine and 100-kilowatt alternator when required. There is a smaller engine-room, affording room for two compound vertical engines of 20 h.p. each, and two dynamos, each being capable of furnishing continuous current for 30 arc lamps for public street lighting. One engine and dynamo will therefore be in reserve, and when another set of arc lamps are required it will only be necessary to provide one additional engine and dynamo. The boiler-house floor is 9ft. below main engine-room floor. Three Lancashire boilers, each 7ft. diameter, 28ft. long, with Galloway tubes, provide steam at a pressure of 120lb. One boiler will always be in reserve. The Corporation have laid mains for the supply of electricity in various streets. Mr. Joseph Lobley is the borough engineer and surveyor, and he has had the superintendence, assisted by Mr. G. H. Cottam, electrical engineer, of the undertaking.

An Action about Shares.—In the Lord Mayor's Court last week, before the Recorder (Sir Charles Hall, Q.C., M.P.), and a special jury, the case of M'Carthy *v.* the Electric Construction Company, Limited, came on for trial. It was a claim by the plaintiff to recover the sum of £2,600, being the proceeds of the sale of 605 shares in the defendant company by whom the plaintiff was formerly employed as clerk and book-keeper. Mr. Pyke, Q.C., and Mr. Edward Turner appeared for the plaintiff, and Mr. Kemp, Q.C., and Mr. Reginald Brown represented the defendants. In opening the plaintiff's case, counsel stated that the proceeds of the shares in question had been received by the defendant corporation. The Electric Construction Corporation was founded, promoted, and formed in the year 1889, at the instance of the Building Society Securities Corporation, at the head of

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which was Mr. Jabez Spencer Balfour. Mr. Balfour was a director, and the shareholders included Captain Dibley, Henry Granville Wright, Hobbs, and Newman, all of whom became shareholders in the Electric Construction Corporation, and some of whom were directors of both companies. In 1889 there were allotted to Captain Dibley 1,712 £10 shares in the corporation which purported to be fully paid up. Five hundred of these shares were transferred to the plaintiff for the sum of 5s Those shares were sold within a few weeks by the defendant corporation for the sum of £2,234. 7s. 6d. The sum was paid by a cheque drawn to M'Carthy or bearer, and was paid by the corporation into their bank. The plaintiff's case was that, having taken the risk attaching to those shares, he was entitled to the sum which they realised. The suggestion of the defendants was that the shares were put into the hands of the plaintiff for sale as the trustee of the corporation, but counsel contended that there was no defence in law as the corporation had no power whatever to deal in its own shares. The plaintiff, as the holder of the certificate, was the legal owner of the shares and entitled to the proceeds of the shares. On November 14, 105 more shares were transferred to Mr. M'Carthy in the same way, and the proceeds of those shares, amounting to £414, were kept by the corporation, they having been sold, and these sums together made up the plaintiff's claim. After the plaintiff had given his evidence, it was submitted on behalf of the defendants that there was no case to go to the jury. After hearing the address of counsel, the jury intimated that they had made up their minds and a verdict was taken for the defendants.

PROVISIONAL PATENTS, 1894.

FEBRUARY 19.

3519. **Improvements in chairs and rails for electric tramways underground channel.** John Wilkinson, 27, Rawcliffe-street, South Shore, Blackpool.

3545. **An electrically-controlled race game.** George Gladman Sarney, 145, Mayall-road, Herne Hill, London.

3548. **Improvements in and relating to electric arc lamps, and mechanism for operating and controlling the same.** Walter Rowbotham, Tintern Lodge, Upper Chorlton-road, Whalley Range, Manchester.

FEBRUARY 20.

3589. **Improvements in electric arc lamps.** Richard Alfred Goodman and Arthur Bernoullé Barlow, 17, St. Ann's-square, Manchester.

3609. **Improvements in mechanical and electrical interlocking in connection with railway signalling.** William Henry Elliott, Railway Cottage, Thurles, co. Tipperary.

3641. **Improvements in ships' telegraph and indicating apparatus.** Thomas Mudd, 6, Lord-street, Liverpool.

3652. **Improvements in the arrangements for working railway signals electrically.** Illius Augustus Timmis, 2, Great George-street, Westminster.

3658. **Improvement in dynamo-electric machines.** Charles James Hall, 433, Strand, London. (Complete specification.)

3667. **Improvements in telegraphic and telephonic apparatus.** The Phonopore Company, Limited, and Edward Wythe Smith, 28, Southampton-buildings, Chancery-lane, London.

3674. **Improvements in primary galvanic batteries and in the liquids used therein.** William Heaton Longsdorf, 73, Cheapside, London. (Gardner Hewett, United States.)

3688. **The electric light cane.** Augustus Hamilton Johnston, 22, Draycott-place, Cadogan-gardens, Sloane-square, London.

FEBRUARY 21.

3725. **Dry or semi-dry galvanic elements.** Thomas Blackhurst, 31, London-terrace, Darwen, Lancs.

3729. **Improvements in dynamo-electric machines.** Ernest Alexander Claremont, 53, Arcade-chambers, St. Mary's-gate, Manchester. (Complete specification.)

3730. **Improvements in electric arc lamps.** Ernest Alexander Claremont, 53, Arcade-chambers, St. Mary's-gate, Manchester. (Complete specification.)

3749. **Improvements in galvanic batteries.** Alfred Julius Boult, 323, High Holborn, London. (Carl Cudell, Iwan Cudell, and Max Cudell, Germany.) (Complete specification.)

FEBRUARY 22.

3841. **Improvements in electric motors for vehicles.** Charles Edward Grove, 28, Southampton-buildings, Chancery-lane, London.

3859. **Improvements in or relating to electric gas-lighting apparatus.** William Phillips Thompson, 6, Lord-street, Liverpool. (Milton Ulmer, Germany.)

3860. **Improvements in dynamo-electric machines.** Alexander Linard, 323, High Holborn, London.

3863. **An improved electric arc lamp.** A. E. Jones, 45, Southampton-buildings, Chancery-lane, London.

FEBRUARY 23.

3897. **An improved bracket for telegraph or other insulators.** William John Hancock, 15, Victoria-street, Westminster.

3902. **A new method of applying electromotors to lathe work.** Arthur Chamberlain and George Hookham, 18, Southampton-buildings, Chancery-lane, London. (Complete specification.)

3922. **Improvements in or relating to the electro-decomposition of metals.** Margaret Roskell, 6 Lord-street, Liverpool.

3926. **Improvements in or applicable to dynamo-electric and other machines or apparatus for the purpose of preventing or retarding the passage of magnetic lines of force from or to such machines or apparatus.** William Morris Mordey, 46, Lincoln's-inn-fields, London.

3931. **Improvements in apparatus for transforming continuous electric currents into alternating currents.** Franz Severin Ferdinand Schneider, 45, Southampton-buildings, Chancery-lane, London.

FEBRUARY 24.

3951. **Improvements in dynamo-electric machines.** Frank Richmond, 79, St. James-street, Burnley.

3962. **Improvements in electrical switches.** Charles Mark Dorman and Reginald Arthur Smith, Ordsal Electrical Works, Salford, Manchester. (Complete specification.)

3976. **A method of utilising the movements of the recorder coil or siphon connected thereto, or the movements of other apparatus used for receiving telegraphic messages through submarine cables or land-lines to automatically transmit telegraphic messages from one submarine cable or land-line to another submarine cable or land-line.** John Boyes, 50, Old Broad-street, London.

3986. **Improvements in electric motors.** William Phillips Thompson, 6, Lord-street, Liverpool. (The Ries Electric Speciality Company, United States.) (Complete specification.)

4921. **Improvements in telephone transmitters and arrangements for same.** Alfred Charles Brown, 129, Algernon-road, Lewisham, London.

SPECIFICATIONS PUBLISHED.

1890.

2296. **Electrolytic production of caustic soda, etc.** Richardson and Holland. (Amended specification.)

1892.

10200. **Electro-chemical production of bleaching agents.** Kellner. (Second edition.)

19714. **Dynamo-electric machines.** Chitty.

23023. **Telephonic news transmitters.** Puskas.

1893.

36. **Electrical station indicators for vehicles.** Villiers-Stead.

2922. **Electric clocks.** Scott and Burnet.

3413. **Telegraph recording instruments.** Muirhead and Edgar.

3690. **Ammeter and voltmeter.** Morris.

4952. **Electrical relays and measuring instruments.** Smith and Granville.

5337. **Conductors for electric railways.** Ewing.

5505. **Moulding bodies of electric switches, etc.** Watkin.

5733. **Reading deflections of reflecting instruments.** Baron Kelvin.

6813. **Electric arc lamps.** Bryan.

6933. **Working railway signals.** Automatic Electric Railway Signal Company and Blakey.

6965. **Electric furnaces.** Urbanitzky and Fellner.

9478. **Insulators for electric wires.** Lake. (Hartmann and Braun.)

10147. **Applying electricity to human body.** Dowling.

19967. **Secondary batteries.** Petschel.

22858. **Electric lighting and extinguishing apparatus for gas burners.** Orling.

24946. **Coverings for electric wires.** Randall and others.

24948 **Time electric switch.** De Segundo and Derham.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	2¾
— Pref.	—	2¼
Charing Cross and Strand	—	5
City of London	—	11⅛
— Pref.	—	13
Electric Construction	—	1⅜
House-to-House	5	1½
India Rubber, Gutta Percha & Telegraph Co.	10	24½
Liverpool Electric Supply	5	6¼
	4½	5½
London Electric Supply	5	1
Metropolitan Electric Supply	—	8⅜
National Telephone	5	4⅜
St. James', Pref.	—	6¾
Swan United	3½	3⅛
Westminster Electric	—	5½

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NOTES.

Rangoon.—It is intended to light the new Government house at Rangoon by electricity.

A Good Example.—The Chelmsford Gas Company desire to be on good terms with the local electric light company.

Lecture.—Before the Royal Institution of South Wales last week, Mr. Alex. Sinclair, A.M.I.E.E., delivered a lecture on "Submarine Telegraphy."

Sanction of Loan.—The Treasury has sanctioned a loan of £9,000 by the London County Council to the Vestry of Islington for the purchase of a site for electric light works.

Smoking Concert.—A successful smoking concert was given last Friday by the employés of Messrs. Drake and Gorham, when about 130 of the London staff listened to an excellent programme.

Description of Works.—The *British and Colonial Printer* of March 1 contains an illustrated description of the electrical engineering works of Messrs. Ernest Scott and Mountain, Limited, at Newcastle.

Visit to Works.—The members of the Leeds Association of Engineers recently visited the works of the Yorkshire House-to-House Electricity Company, in Leeds. Mr. R. W. Eddison conducted the visitors round the station.

Thames Embankment.—The Highways Committee of the London County Council on Tuesday again recommended the carrying out of the electric lighting of the Victoria Embankment. The matter was, however, postponed.

An Electrical Inspector.—The City Commission of Sewers, on the recommendation of the Streets Committee, resolved on Tuesday to appoint an electrical inspector under the Electric Lighting Act at a salary of £250 per annum.

French Electric Locomotives.—Persons travelling to Nice will, a Paris correspondent says, shortly see the new electric locomotives which the Paris-Lyons Company is building at the Oullins works, near Lyons, for its fast express traffic.

Students of the Institution.—A students' meeting of the Institution of Electrical Engineers will be held on Friday next, the 16th inst., at 28, Victoria-street, S.W. A paper will be read on "The Construction of Resistances" by Mr. D. K. Morris.

Junior Engineering Society.—As stated in our last issue, a paper will be read before this society this (Friday) evening on "The Design, Construction, and Working of Boilers for Locomotive Engines," by Mr. G. Frank Burtt, G.I.Mech.E., member.

Rectifiers.—A passage of arms is taking place between Mr. Massey and Mr. Sydney F. Walker, in one of the South Wales newspapers, concerning the merits or otherwise of the rectifiers proposed to be introduced in Cardiff, and the system of mains adopted there by Mr. Massey.

Bethnal Green.—Mr. T. H. Rippin expressed the hope on Wednesday evening, at a meeting convened to protest against the charge by the Gaslight and Coke Company of 3s. 1d. per thousand for gas, that the Bethnal Green Vestry would take in hand the subject of introducing the electric light.

St. Pancras.—The Vestry have declined to accept the terms of the London County Council for a loan for electric lighting purposes for the period of 25 years. They have decided to borrow from the Prudential Company at the same rate, and for the original period of 42 years.

A Bicycle Electric Railway.—A railway on the bicycle system, devised by Mr. Boynton, is now in process of erection across Long Island, from Bellport to the Sound. The idea of the bicycle railway is to provide a system of transit whose speed may be from 75 to 100 or more miles an hour.

Lighting of Londonderry.—Mr. Charles P. Cotton, M.I.C.E., engineering inspector under the Local Government Board, has held an enquiry in connection with the application by the Corporation of Londonderry for sanction to a supplemental loan of £5,000 to complete the electric lighting works.

Castle-Lighting.—Prince Bismarck's castle at Friedrichsruhe has been recently lighted by electricity, the power being derived from some sawmills which belong to the Prince, situated within a short distance of the castle. The Elektrizitäts-Gesellschaft, of Hamburg, formerly known as Schuckert and Co., carried out the installation.

Coventry Electric Tramway.—It is reported that arrangements are now completed for the commencement in two or three weeks of work on the tramways, and that it is expected the cars will begin running in the summer. The electric cars will run to Bedworth, a distance of over five miles, with a 10 minutes' service to and from Longford.

Telephony.—During an experiment with the telephone between Trieste and Berlin the other day, the official in Berlin began by singing an air from the operetta "Die Vogelhändler," and the one at Trieste answered by an air from "Cavelleria Rusticana." It was noticed that the singing was heard perfectly, while mere speech was confused and indistinct.

Engineering Works near Wolverhampton.—Rumour is again current that arrangements have been completed for the erection and equipment of works on a large scale, near Wolverhampton, for the manufacture of dynamos and other electrical apparatus. The establishment will, it is said, be the property of a joint-stock company now in process of formation.

Scarborough.—The Mayor of Scarborough (Mr. G. L. Beeforth, J.P.) was "At Home" on Wednesday of last week at the Grand Hotel, and received over six hundred ladies and gentlemen in the banqueting hall. The Scarborough Electric Supply Company gave an exhibition of electrical appliances. Mr. A. A. Campbell Swinton, the managing director of the company, conducted a series of experiments.

Institution of Civil Engineers.—On Tuesday next, the 13th inst., the following papers will be further discussed: "The Liverpool Overhead Railway," by Messrs. J. H. Greathead and Francis Fox, MM.I.C.E.; and "The Electrical Equipment of the Liverpool Overhead Railway," by Mr. Thomas Parker, M.I.C.E. If time permits, a paper will be read on "The Prevention and Detection of Waste of Water," by Mr. Ernest Collins, M.I.C.E.

Telephony between Berlin and Copenhagen.—The first step has been taken towards the establishment of telephonic communication between Copenhagen and Berlin. The Finance Committee of the Folksthing has reported in favour of the proposal of the German Telegraph Department that the cable between Copenhagen and Odensce shall be so laid as to form a part of the eventual telephone line to be carried *vid* Odenser, Kolding, and Hamburg, to Berlin.

Northern Society of Electrical Engineers.—An ordinary general meeting of this society will be held on Monday next, the 12th inst., at the Palatine Hotel, Hunt's Bank, Manchester, commencing at 8 p.m. Mr. John H. Rider is announced to read a paper, entitled "Notes on

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Designing a System of Underground Electric Light Mains," whilst Mr. S. V. Clirehugh will present a paper on "The Various Systems of Underground Mains and Methods of Laying Same."

Newcastle.—The Mayor, in referring to the tramways at the annual dinner a few days ago of the Newcastle Association of Students in connection with the Institution of Civil Engineers, said that it was quite possible that in eight or ten years the electric system might be found superior to the cable system. It was necessary therefore, he observed, to move with caution before making the change recommended by a committee of the Town Council for the substitution of the cable system for horse haulage.

Combined Telephone and Telegraph System.—A telegram from Berlin states that a Russian inventor, M. Gwozdef, claims the discovery of a new telephone ystem whereby spoken messages can be transmitted over very great distances wherever an ordinary telegraph line is aid, and without in any way interfering with the telegraphic despatches. As M. Gwozdef considers his invention invaluable in case of war or sudden mobilisation, he has resigned all claims to it in favour of the Russian Government.

The Douglas Tramway.—With reference to the note on this subject in our last issue, we observe that the Isle of Man Tramway Company have now decided to sell their undertaking to the Douglas and Laxey Electric Tramway Company for £38,000. It would be interesting to learn who are the shareholders in the latter, and who should understand, even if they do not, that the tramway system can be acquired by the Douglas Commissioners in four years hence for £25,000. It is a pity for money to be, as it appears, thrown away in this manner.

The Kinetoscope.—A telegram from New York on Wednesday announces that Mr. Edison has now perfected his kinetoscope for the continuous photography of objects in motion. By means of this invention it is said that he can take a number of impressions by means of a camera in a very limited space of time, thus obtaining a continuous photograph of the entire motion of the object or person selected. The photographs follow each other in such rapid succession that no lapse of time can be detected between the impressions recorded, and the series becomes in effect but one picture.

Projected Electric Railway in Denmark.—An application, according to *Engineering*, has been made to the Danish Government for a concession for an electric railway from Klampenborg to Humlebök, both on the Sound, a distance of some 16 miles. The plan does not include any contribution from the State, nor from the districts through which it will have to pass. It is principally intended for passenger traffic, only secondarily for goods. The Danish Government has proposed a railway from Klampenborg to Elsinore, which would entail an expenditure of some £350,000, whilst the proposed electric railway will not cost the State anything, in addition to which the Parliament does not seem disposed to pass the Government's Bill.

Chelsea Company's Preference Shares.—As notified in our advertisement columns, the Electric and General Investment Company, Limited, of 1 and 2, Great Winchester-street, E.C., invite subscriptions for 6,000 6 per cent. preference shares of £5 each in the Chelsea Electricity Supply Company, Limited. The shares, which are offered at a premium of 10s. per share, will be entitled to be paid yearly out of the profits a preferential dividend at the rate of 6 per cent. per annum. The nominal capital of the company, of which £88,785 is paid up, is £100,500, and the additional capital now sought is required for the extension of mains into a fresh district in Chelsea, and to defray the cost of the buildings, works, and machinery necessary to enable the company to cope with the increasing demand for current. The lists of subscriptions opened on Tuesday, the 6th inst., and will close for both town and country on Tuesday next, the 13th inst.

The Konigsberg Electricity Works.—This station is one which is of considerable interest among German stations, and is remarkable chiefly for two features: its circuits are on the five-wire system, and the mains are laid in conduits. The engines are of triple-expansion vertical type, and by Schichau, of Elbing; there are two of 200 h.p. and two of 100 h.p.: they run at 200 revolutions a minute, and are directly coupled each to two multipolar dynamos, which have the outside wires of their disc armatures arranged as commutators. Very full descriptions are given in the columns of a German electrical journal of the circuits of the five-wire supply, and also of the conduit in which the five conductors of bare copper strip are carried on insulators of the telegraph type. These mains are calculated for 60,000 lamps, but the present station can only supply 16,000. All details given are very full, and the financial results, in spite of the disproportionately heavy outlay on mains, are stated to be satisfactory.

A Phenomenon of Electromagnetic Rotation. In a recent issue of the *Elektrotechnische Zeitschrift*, Mr. M. Jüllig referred to a phenomenon of this character. He states that if a hollow copper ball be suspended by a thread in the field of an electromagnet the coils of which are traversed by an alternating current, a turning moment is generally produced in the ball, causing it to rotate. This rotation, however, does not take place (1) if the centre of the ball lies in the plane at right angles to the plane of the magnet and to the line joining its poles; (2) if the centre of the ball lies in the plane of the magnet. In every other position the ball rotates without being artificially started; but it is necessary to work with large forces, as the rotation is due to a small difference of impulses. A diagram of the poles and ball in plan will show that each pole makes an induced current in the sphere, and the resultant current is more strongly acted on by one pole than by the other. The phenomenon might possibly be used in the construction of an ampere-hour meter for use with alternating currents.

Some Notes on Brush Discharges in Gases.—A remarkable difference between the behaviour of positive and negative electricity in high-frequency discharges, which was observed by Messrs. W. H. Harvey and F. Bird, forms the subject of a note by them in the *Philosophical Magazine*. The arrangement of apparatus is as follows: A small magneto excites the primary of an induction coil whose secondary can give about an inch spark with eight volts on the primary. The terminals of the secondary are connected to two condensers of similar capacity, about $38/10^4$ microfarad, and also to the two balls of a spark-gap. The other coatings of the condensers are connected through the primary of an air transformer, whose secondary is utilised to produce high-potential and high-frequency brush discharges. The discharges, which were always vivid, were most brilliant when allowed to take place between a point and a plate having some capacity, and this plate had always a positive charge, though the discharge was of course oscillatory. The details of the experiment were varied in every way, but the plate always remained positive. If either end of the transformer secondary were connected to the plate, and the other end immersed in oil, the result was always the same—a strong positive charge. If the

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discharge was made to take place in dry hydrogen, the reverse result was obtained, the charge being negative. It appeared probable that a negative charge passes more easily in hydrogen than a positive. Oxygen behaved like air, the charge on the plate being positive. These results have been to some extent anticipated, Guthrie having shown that a red-hot conductor in air retains a negative, but not a positive, charge.

Multiple Switchboards for Telephony. — The general interest manifested both by practical men and the public in the development of telephony may have inspired the late director of the German Government telephone service, Mr. J. Sack, to write a pamphlet, which we now have before us. It is entitled "Telephonbetrieb mit Klappenschranken mit Vielfachumschalter," and is published by Messrs. F. A. Gunther and Sohn, of Berlin, at the price of one shilling. The author has been connected with the general management of the German Government telephone exchange service almost since it was established, and in comparing the three systems of multiple switchboards now in use at the leading telephone exchanges in the world, he concludes in favour of the latest invention, which has been in successful operation for the last 12 months in the German telephone exchanges. Mr. Sack compares the system of Scribner, Kellogg, and of Mix and Genest, illustrating each system by means of diagrams, and fully describing advantages and disadvantages of each system. Although written in German, we have no doubt that telephone engineers without any knowledge of that language will be able to gather sufficient information from the diagrams. The author decides in favour of the multiple switchboard constructed by Messrs. Mix and Genest on account of the impossibility of delays on the part of the operator at the exchange. The separate test line is entirely dispensed with, and the operator need not strain her ear as she tests with the galvanometer, thus relieving the operator physically. The disconnection of two subscribers during a pause, which is not an unfrequent occurrence, cannot take place in this system of testing the line. The pamphlet is well written and printed, and can be recommended to those interested in telephony.

The Phonograph and Microphone in Medical Studies.—At the conversazione held recently in Glasgow, Dr. Macintyre exhibited a number of new electrical instruments, as well as some interesting micro-phonographic records. With the perfection to which the instrument has now been brought, says *Industries*, the phonograph is not unlikely soon to take its place as an instrument of instruction in medical teaching. Dr. Macintyre was able to demonstrate a number of cough sounds and varieties of hoarseness due to different pathological conditions; and he has been able by special recording arrangements to register the heart sounds. Doubtless, stethoscopic sounds offer the greatest difficulty of all, but by properly arranged conducting apparatus fairly good records have been obtained of different sounds heard within the chest. Dr. Macintyre also exhibited a number of microphones—some of the ordinary varieties and others adapted specially for medical purposes. The principal one of interest was an instrument enabling a number of students to listen to the sounds of the body at the same time, and also to transmit these sounds to a distance. Dr. Macintyre showed how these might be utilised so that students in a classroom of a medical school could hear the chest sounds of a patient in a hospital at a distance. The slight disadvantage of the apparatus at present is that it is extremely sensitive, so that other sounds may sometimes be heard at the same time. The apparatus consisted of a microphone specially adapted for application to the human body, an induction coil to transmit sounds to a distance, and a small battery and telephone receivers, of which the Ader has been found to be the best. By such means it will doubtless be possible to fit up medical schools so that large numbers of students may be trained at the same time to appreciate the sounds heard within the body, even though the patient may be at a considerable distance, and with improvements in the recording apparatus of the phonograph to take permanent records of the same.

The Altona Central Station.—A recent issue of the *Elektrotechnische Zeitschrift* contains a description, by Mr. F. Uppenborn, of the Altona electricity works. The system used at Altona is similar to those of Barmen and Hanover in the use of comparatively large accumulator storage in combination with a three-wire system; but it differs in many interesting details, especially in the use of an earthed middle wire—a principle which found application here for the first time. The first difficulty was that of water, of which the supply was not sufficiently large, and a well was sunk to a depth of 200ft. to obtain the amount required. The construction was begun on July 14, 1891, the first run was on February 1, 1892, and the official opening took place on March 15; the preliminary installation being for 24,000 30 watt lamps, and the space provided sufficing for 80,000 lamps. The machinery consists at present of two boilers, by Berninghaus, of Duisburg, and two vertical triple-expansion engines with jet condensers, by Schichau, of Elbing, fitted with all conveniences, and coupled directly to the dynamos, which are the ordinary Schuckert disc armature machines of 250 kilowatts output, of a height of about 10ft., and having commutators about 6ft. in diameter, with 700 sections. To prevent side pull, the armature is adjustable between the poles; the volts are from 220 to 350, and the amperes 800 to 1,000. Complete details of connections and measuring apparatus are also given in the text, also of the accumulators and cable system. In order to avoid telephone and telegraph disturbances, the middle wire has been laid bare; and this has hitherto been quite successful in preventing disturbance, even when short circuits take place. The cables are laid directly in the ground, as usual in Germany, and protected by U-iron at crossings, etc. The tests resulted as follows: 7·41b. of steam per 1lb. of coal, 86·5 per cent. of the heat in the coal being utilised. The steam-engines used 15·5lb. of steam per indicated horse-power, and the average efficiency of each steam-dynamo was 82 per cent.; and 0·78 electrical horse-power hour was produced per kilogramme of coal burnt. The automatic constant-current system of charging the cells has been employed here with excellent results.

The Pacific Cable Question.—The Postal Conference arranged towards the close of last year between the Governments of the various Australasian colonies was opened at Wellington on Monday, under the presidency of Mr. J. G. Ward, Colonial Treasurer, Postmaster-General, and Minister of Trade and Customs for New Zealand. The colonies of New South Wales, Victoria, South Australia, Queensland, West Australia, and Tasmania were represented, either by Ministers or by the chief officers in charge of the Post Office departments. On Tuesday the proposed Pacific cable was reconsidered. The various schemes which have been formulated for laying a cable to connect Australia with North America was discussed, and the conference declared itself in favour of a line starting at Bundaberg, in Queensland, and proceeding thence to Samoa, Fanning Island, Honolulu, and Vancouver. This was regarded as a most feasible commercial route for a cable under the Pacific, and as being likely to enlist the support of Great Britain, Canada, the United States, Germany, and France. When the conference resumed on Wednesday Mr. Ward moved: "That,

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considering the important interests involved, both of a national and commercial character, in the establishment of a Pacific cable, the representatives of the respective colonies assembled at this conference recommend their Governments to consider the desirability of entering into an agreement with the other countries interested, for a period not exceeding 14 years, to guarantee the interest at the rate of 4 per cent. per annum on a capital of not more than £1,800,000 to any company undertaking to lay a Pacific cable, on condition that the tariff charged does not exceed 3s. per word for ordinary telegrams, 2s. per word for Government telegrams, and 1s. 6d. per word for Press telegrams to and from Great Britain and the colonies; the United Kingdom being asked to join in the guarantee, and the routes of the cable being either of the following: Brisbane to Ahaipara Bay (New Zealand), Suva, Apia, Fanning Island, Hawaii, and Vancouver, or from New Zealand by the same route to Vancouver." The motion was seconded by Mr. John Kidd, the Postmaster-General of New South Wales, and after a lengthened debate the matter was adjourned.

Messrs. Crompton and Co.'s New Catalogue.—It is now some four years since Messrs. Crompton and Co. issued a complete catalogue of electrical machinery and apparatus, and during the interval very considerable progress has been made in the many different applications of electricity. Mr. Crompton, it will be remembered, visited the Paris Exhibition in 1878, and brought back with him two Gramme dynamo machines, which formed the commencement of the now well-known works at Chelmsford. Since that time the business of the company has been extensively developed, and, in addition to having three large works, the company have important agencies in nearly all parts of the world, as, for instance, in Australia, Germany, Russia, France, Rangoon and Burmah, Japan, and Bengal and North-West Provinces. The three works in question are respectively at Chelmsford, where heavy machinery is constructed; at Lillie-road, London, S.W., for light machinery; and at 158, Brompton-road, S.W., for what the company are endeavouring to largely popularise—namely, electric heating and cooking apparatus for use in hotels, clubs, and restaurants, and for domestic purposes; whilst the chief offices are situated at 4, Queen Victoria-street, E.C. The present has been deemed an opportune moment to bring out a new catalogue, and the copy lying before us may be regarded as one of the most complete in the country. For convenience of reference, the catalogue, which is largely illustrated, has been divided into sections. The first comprises notes, data, and prices relating to dynamos, motors, and steam-dynamos. Here one finds practically all information that a purchaser may desire on Crompton machines, single, or coupled direct to a Willans or Chandler engine, or to a Belliss engine for shiplighting. In the second section, the applications of motors for driving lifts, pumps, and haulage engines for colliery purposes, cranes, electric tramcars, and for other purposes requiring power for industrial processes, etc.—and in which direction the company have taken a very prominent part—are fully set forth. The Crompton-Brunton alternate-current system forms the subject of the third section, and in this connection it is noteworthy that the company are fully competent to deal with alternating-current plant, as, indeed, they have done so in various cases. The next section treats of arc lamps, lamp-posts, brackets, lanterns, projectors, etc., and in this field, too, the company are meeting with success, and particularly in regard to the Crompton-Pochin arc lamp. The remaining sections relate to measuring instruments, notes, data, and estimates of cost of the electrical transmission of power, controlling apparatus, switchboards, and to underground mains on the Crompton and Crompton-Davies systems. A long list of testimonials, referring to central stations and private installations carried out by the company, affords abundant proof of the high-class character and efficiency of the work executed, and forms an appropriate conclusion to this extremely useful catalogue, of which a revised but smaller edition for the pocket will shortly be issued.

Indicating the Position of Ships in Harbour.—Mr. Charles A. Stevenson has been making experiments for locating the position of vessels at harbour entrances, which would be of service when, during certain states of the weather, other observations cannot be easily made. He proposes that a cable might be laid down in the sea, and by changing the electric state of the cable, vessels passing near or over it might be able, by means of a detector on board, to discover that they were in its vicinity. Some experiments showed the method to be feasible, since the sea offers no insurmountable difficulty, and he has constructed two instruments which will act through 180ft. of water. The first instrument is a coil of uninsulated copper-wire rope dipping into the water at the bow of a boat, and a similar water connection at the stern. If these are joined by a wire with a telephone on the circuit, it will be found that even without an induction coil or other arrangement to magnify the effect, a very sensitive instrument is produced, and that, when the wires from bow to stern of the boat are at right angles, or nearly so, to a cable laid in the water at some distance from it, the sounds produced by a magneto-electric machine connected to one pole of the machine are audible in the telephone. If the water connections are equidistant from the cable, as they would be if the boat were immediately over the top of it, or lying broadside on, no sound is heard. The action takes place when the coils in the water are insulated. The cable also may be insulated or uninsulated. The action is similar with an induction coil, and will also act if the potential of the cable is charged and is then kept so. With the coils separated 10ft. (at the bow and stern of a small boat put down from the vessel) and an insulated wire 400ft. in length laid through a small lake of brackish water 15ft. deep, the alterations produced by the bobbins of a magneto-electric machine were perfectly distinct at the end of the lake 340ft. away from the wire, and the limit of audibility could not be ascertained. Further trials will be necessary to determine the law of the falling-off of the intensity of the sound with the increase of the distance from the cable for a given fixed distance between the water connections, as well as to determine the law of increase of intensity for any increase of distance between the bow and stern connections for a given fixed distance from the cable. Mr. Stevenson's second instrument is a coil of insulated wire surrounding a core (that is, an electromagnet with a telephone in the circuit of this coil). With this instrument the making and breaking of the current produced through a wire 200ft. in length could be detected through 60ft. of salt water. When sunk in water the sound seems just as loud. He is of opinion that the action of the instrument consists in the break, if broken sufficiently rapidly, including a current in the coil, which the core intensifies immensely. The sound in a Bell telephone with the instrument was almost deafening with 15ft. depth of water. This electromagnet system of induction, in contradistinction to the parallel-wire systems, has no earth connection, being entirely insulated, and must therefore be a case of true induction through water.

Lighthouse Illuminants.—In the course of an article on this subject, the *Times* says: "It is doubtless within the public memory that the prolonged investigation at the South Foreland about 10 years ago into the relative merits

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of oil, gas, and electricity as lighthouse illuminants resulted in a declaration by the Trinity House Committee that, for all practical purposes, the lights of oil and gas were about on an equality, oil being somewhat cheaper, and that the electric light was most suitable for salient points and landfalls, for which the longest possible range is desirable for the lights intended to mark such points. Generally speaking, the matter stands now where it was left by the Committee of Investigation. The conclusions then arrived at have not been seriously disputed; indeed, they have been practically accepted by the French, American, and other foreign lighthouse authorities as fairly representing the facts of the case. But progress has been made in developing the possibilities of each illuminant. Electric lights are being made more powerful than ever. With the continued advance of knowledge respecting the generation and utilisation of powerful electric currents and the adaptation of lenticular apparatus to arc lights so produced, most wonderful effects are now being exhibited. It is not long since St. Catherine's Point, in the Isle of Wight, was lighted with the most powerful electric light then known. Some few years later in the lighthouse on the Isle of May, in the Firth of Forth, was installed an electric light whose power greatly exceeds that of the St. Catherine's beam. Now we hear that in France they have electric lights transcending in power and distinctiveness everything on this side of the English Channel. The British Government some time ago agreed that luminous intensity could only be expressed satisfactorily in candle-power, and the engineers of the three general lighthouse authorities for England, Scotland, and Ireland were authorised to determine the candle-powers by actual measurement of all the lights as issuing from the lighthouse lanterns. Measurements were accordingly made in the photometric-room at the South Foreland, where types of every burner, associated with exemplar lenses, were measured under the joint direction of the three engineers—Mr. T. Matthews for the Trinity House, Mr. D. A. Stevenson for the Scottish and Mr. William Douglass for the Irish Lighthouse Board. The results so gained were expressed in candles, and each record was the mean of a great number of photometric observations. The figures were then submitted to a conference, which agreed to accept the figures given as applicable to the oil and gas lights. With the electric lights some difficulty has been experienced. It is well known that considerable doubt exists respecting the extraordinary candle-powers claimed for electric lights, based mainly on the electrical energy developed for producing such lights. There seems, indeed, to be some difficulty in bringing the bluish arc light to an effective comparison with the yellow light of a candle, and the most practised photometrists are not absolutely certain that they can make the comparison accurately. This question is therefore for the moment standing over, in order that actual measurements of the lights may be made with the most approved means. The conference hesitated to publish officially figures based on imperfect data, and this matter is now receiving careful attention with a view to a trustworthy determination being arrived at.

The Electrolysis of Sea-Water.—The experiments now being made at Worthing with the Hermite process are attracting considerable attention, and the opinion of a *Lancet* correspondent on the subject will prove interesting. The correspondent states: "The Hermite system of sanitation is based on the use of what is declared to be a very powerful disinfectant liquid obtained by submitting sea-water, or a solution of common salt and chloride of magnesium to the action of a current of electricity in a machine called the "electrolyser." The magnesium chloride is alone decomposed, the chemical affinity between the positive element magnesium and the negative element chlorine being distinctly weaker than that existing between the elements of common salt; but the undecomposed sodium chloride serves as an electrical conductor. The exact nature of the changes produced in sea-water by this treatment is not perfectly understood, but it is well known that when a current of electricity is passed through a solution of common salt (NaCl), which is divided loosely into two columns of liquid by a diaphragm of parchment, or, if the experiment be performed in a V-tube, with an electrode in each limb, caustic soda appears at the negative pole, and chlorine at the positive. These products, however, if left to diffuse would combine, according to the equation $2NaOH + Cl_2 = NaClO + NaCl + H_2O$, and form sodium hypochlorite. This is probably what takes place in the electrolyser of M. Hermite, except that hypochlorite of magnesium is formed which yields its chlorine more readily than the corresponding sodium salt. The action, however, is not so seemingly simple, since other bodies of a powerfully oxidising nature are invariably associated with the electrolytic products. The Hermite fluid has a slight but not unpleasant chlorous odour, is said to be neutral to test-paper, and rapidly displaces iodine from potassium iodide. It possesses distinct bleaching properties, and this fact introduces some doubt as to whether the process is applicable to inland towns since the discharge of a chlorinated liquor into rivers would most probably prove fatal to fish. The electrically-treated sea-water, the strength of which is regulated by the rate of flow through the electrolyser, is pumped into elevated tanks, from which the water-closets of the cottages in the row in West-street are supplied. The closet evacuations flow first into an intercepting syphon, and this is an essential feature in the system, inasmuch as it is claimed that all accumulated solids are gradually disintegrated and dissolved by the passage of a constant supply of electrolysed sea-water through the syphon. There was an accumulation of paper and soap and other sewage concomitants in this syphon, which represented the product of three weeks' use of the sewer. The quantity of deposit was certainly considerably less than one would expect to find in the case of untreated sewage, while it was quite free from fæcal odour. It is even advanced that such things as paper are gradually broken up by the modified sea-water. In an interview with M. Hermite, which he freely accorded me, I expressed myself somewhat incredulous on various points. His replies are of interest. Thus, on the question of the possible injurious action of the fluid on service pipes and reservoirs, he said that it has a preliminary action on iron, which, however, is soon arrested by the protective crust of oxide first formed. In bleaching factories all the machinery is of iron, and it shows little or no deterioration after several years' use. It would be possible, he added, to use earthenware or cement pipes; but they were absolutely unnecessary, for he was prepared to guarantee that tarred iron pipes would prove satisfactory. The pipes and tanks used in the experiment at West-street were of galvanised iron, and after some time they would be found to be coated with a protective layer of magnesic oxide. On the question of cost M. Hermite said that to supply the inhabitants of Worthing with not merely enough water for the closets, but also for domestic use—to enable them to have, in fact, a disinfectant to use for washing floors, sick-chambers, and so on—would cost about 1s. per head per annum of the population; that would mean about 40 litres (nearly nine gallons) per head per day. But for closets only, leaving a margin for town purposes, it would cost about 6d. per head per year of the population."

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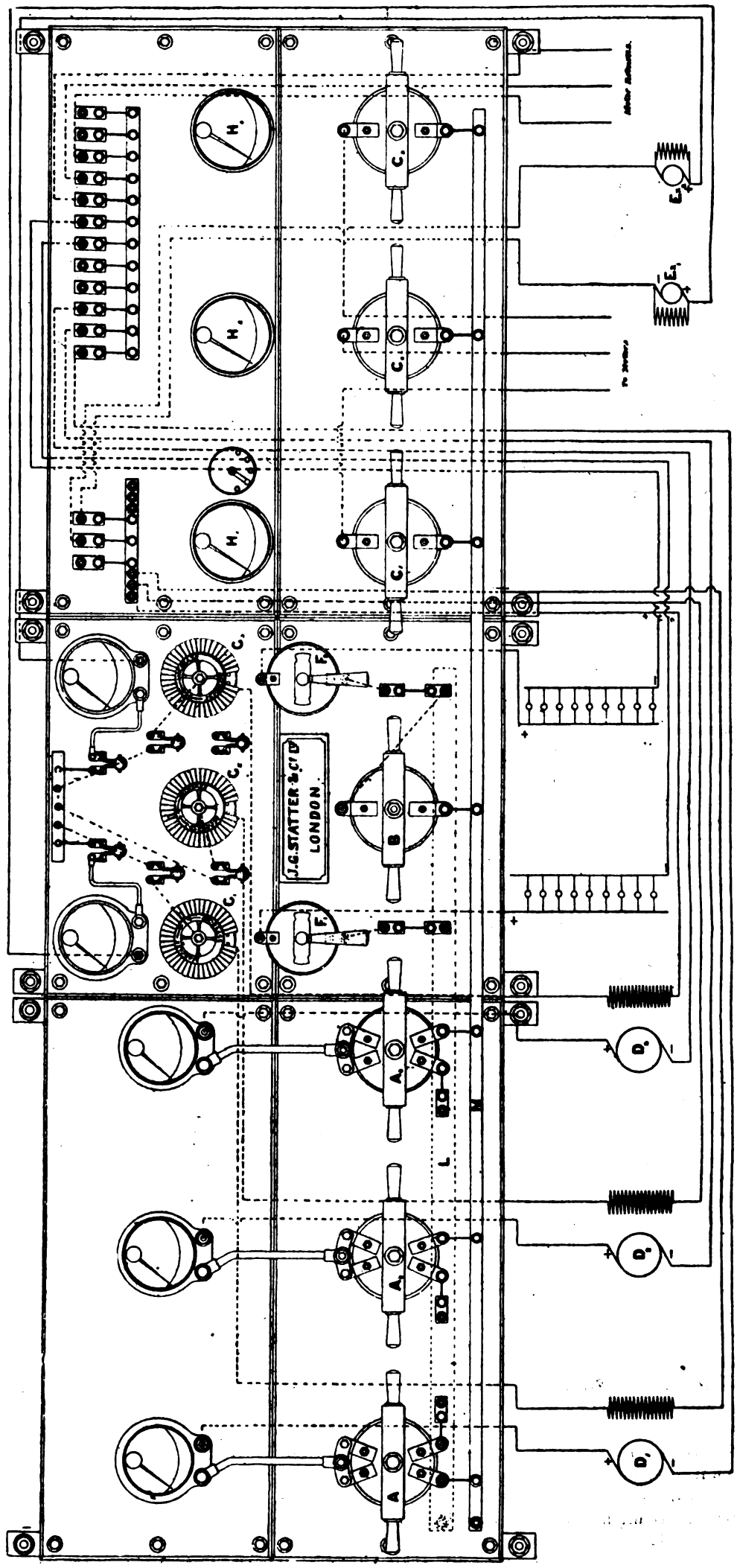
SWITCHBOARD FOR LIGHTING AND MOTOR CIRCUITS.

For some time past there has been in active operation at the works of Messrs. W. T. Henley's Telegraph Works Company, Limited, an electric generating station of considerable size supplying current to lights, both incandescent and arc, as well as to a number of motors throughout the different shops and departments in the works.

When finally completed the plant will be capable of an output equal to nearly 500 h.p., there being eight Crompton dynamo generators then erected of 50 h.p. each, driven by belts from two countershaft extensions coupled to the crankshafts of high-speed vertical compound engines made by Belliss and Co.

Perhaps the most interesting feature of the installation, from an electrical point of view, is the main switchboard erected on one side of the engine and dynamo room, and which we illustrate herewith in diagrammatic form. In the engraving, D_1, D_2, D_3 represent the three large generators at present installed; the current from their positive terminals passes through ammeters placed on the top left-hand side of the board, and thence to a two-way switch, A_1, A_2, A_3, for each machine. These switches serve to join up any of the dynamos to one or other of two positive omnibus bars, L, M, connected respectively to the lighting and the motor circuits; M, as will be seen, is mounted on the front of the board, whilst L is at the back. The connecting links are formed of fuse wire, so that a system of double-pole fuses exists.

Both positive bars may be coupled together for running in parallel by means of the switch, B, similarly provided with fuse links. The system of distribution adopted is that of a simple two-wire parallel at low voltage, the pressure employed being 110 volts. The switches marked C_1, C_2, C_3 control the motor circuits, whilst F_1, F_2 serve as main switches for the lighting circuits. All these switches



Switchboard for Lighting and Motor Circuits, as erected at the works of Messrs. W. T. Henley's Telegraph Works Company, Limited, North Woolwich

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are of the ring contact type, in order to ensure plenty of surface in actual hard contact. Ex_1, Ex_2, represent the two exciting machines employed to furnish current for the generator fields, and G_1, G_2, G_3, are regulating switches which control by means of step-by-step resistances the exciting current through the field coils, hand regulation being found sufficient to keep the voltage constant, even under the heavy variations of motor work.

Of the six small switches grouped near the latter, three—as may be seen by tracing the connections—serve to cut in or out the generator fields; two others convey the main current from exciter dynamos through ammeters to a small positive bar at the top of board (whence connections are made with the three switches just mentioned); the sixth is a spare.

At H_1 is a voltmeter for testing the pressure of each generator, an adjacent five-point switch allowing each machine to be tried before switching in or out of main circuit: H_2 and H_3 are similar instruments for measuring the voltage of the lighting and motor positive omnibus bars.

The switchboard thus described has been made by Messrs. J. G. Statter and Co., Limited, to the designs of Messrs. Kincaid, Waller, and Manville, who have acted as consulting engineers upon this installation.

ALTERNATING CURRENT AND THE LOW-TENSION DISTRIBUTING NETWORK.*

BY E. PARRY, B.SC.

My object in bringing this subject before you is to show how, in designing a network which is supplied by an alternating current, the extra drop due to inductance, over and above the drop due to dissipation of energy in the copper, can be taken into account with very little extra trouble over that entailed in designing a network for continuous currents. Engineers have been so accustomed to deal with quantities involving, for the purposes of calculation, their magnitudes alone, that the vector properties of the quantities involved in alternating work are apt to be overlooked, or, if recognised, shunned, though there is no further difficulty than that of applying the laws governing the manipulation of complex quantities given in every textbook on algebra. Oliver Heaviside has evolved a complete vector system for the treatment of physical quantities in general with particular application to electromagnetism, but in ordinary engineering practice we are mainly concerned with maximum values or the square root of the mean square of the values of harmonically varying quantities, for which the simple laws of vector algebra suffices, with the application of which we are now becoming familiar through the efforts of Heaviside, and, more recently, to Steinmetz and Kennelly. Given the complex expression $(R+ipL)$ for the impedance of a coil, and $(K+ipC)$ for what Heaviside calls the admittance of a condenser, or leyden (where R = resistance of a circuit, L = induction, K = conductance of dielectric of the leyden, C = capacity of leyden, $p=2\pi n$, where n = number of alternations per second, $i=\sqrt{-1}$), then the sum of a series of impedances and admittances or the resultant of a multiple circuit of impedances and admittances are as easily expressed as the corresponding simple quantities.

For instance, the sum of any number of impedances, R_1+ipL_1; R_2+ipL_2; R_3+ipL_3, etc., is

$$\{(R_1+R_2+R_3+\ .\ .\ .\ )+ip\,(L_1+L_2+L_3+\ .\ .\ .\ )\},$$

and the sum of the several potentials, $C\,(R_1+ipL)$; $C\,(R_2+ipL_2)$, etc., as measured by a voltmeter will be

$$C\,\{(R_1+R_2+R_3+\ .\ .\ .\ )+ip\,(L_1+L_2+L_3+\ .\ .\ .\ )\}$$

volts, as measured by a voltmeter, the terminals of which includes the whole in series if C = current in amperes as measured by an ammeter. Equally simple is the process of finding the resultant of any number of impedances and admittances in parallel on the principle that the reciprocal of the impedance of the compound circuit equals the sum of the reciprocals of the individual components, provided that there is no mutual action between the circuits, and we have as a result an expression of the form $(A+iB)$: for the product and dividend of complex quantities yields another complex quantity.

For such cases this method is much simpler than the ordinary Cartesian projection method, and has the merit of not obscuring the vectorial significance of quantities concerned, which indeed may be said to be the *raison d'être* of Heaviside's methods. I need not do more than just indicate the processes before this society, and I proceed at once to the main object of this paper, which is to describe the application of these principles to network design.

To illustrate the principle it will be quite sufficient to consider a network on the two-wire system. Given the detailed demand for any area, it is comparatively simple to plan the network for that area for a continuous current with the limit of drop allowed by the Board of Trade at maximum load. I mean, of course, only as far as the arithmetical process is concerned, and apart from the advantage of an almost unerring judgment that enables men of experience in such work to design off-hand the most economical distribution of copper. Arithmetically, all that is necessary is to see that the sum of the individual $C \times R$ "drop" between the feeding points and neutral points does not exceed at full load that which would bring the potential below the Board of Trade limit. But for alternating work, a most grievous mistake would be made if inductance were neglected—that is, if the several "drops" are not summed vectorially—unless it is recognised that the drop is not $C \times R$, but $C \times (R + ipL)$. The consequence will be that the volts obtainable at the farthest or neutral points will be much less than the Board of Trade limit—as much as 4 or 5 per cent. below, for a distance of 6in. between centres in an area of one-tenth of a square mile, for circuits of unit inductivity of medium and material—even if the feeding points be at the potentials estimated for. Another consequence will be that at each junction the current will divide inversely as the impedances and not as the resistances, and so upset the intended distribution of current through the feeders, and perhaps through the load on a feeder, the least to be desired, but having regard to the vagueness and uncertainty in the best possible estimate of demand this last is relatively unimportant. Usually the influence of self-induction upon the effective "drop" in a network has been neglected upon the plea that the self-induction is small; the values met well do certainly seem insignificant. From 10,000cm. to 20,000cm. are the values usually met with in this class of work, but the true criterion is the time constant, $\frac{L}{R}$, of the circuits; thus in a part of a network, say, 100 yards long and 6in. between centres, and for a 0·15 square inch conductor of 1·0 square inch section, the effect of self-induction upon the drop may be negligible, but for a feeder having the same value of L, the ratio $\frac{L}{R}$ is such that the inductance of the circuit cannot be neglected. In other words, the relative values of L and R determines the direction of the vector, which is of equal significance with its magnitude—*i.e.*, it determines the lag, which differs enormously in the two cases. The same reasoning applies to armatures. Armatures with no iron in them are said to have negligible inductance, and such figures as ·002 secohm or 2×10^6cm. are quoted. Nevertheless, when the quantity pL (where $p=2\pi n$) is compared with the resistance, R, of the armature, self-induction is everything, and is far and away the chief factor in the expression for impedance.

To mark a network according to the above principles seems formidable, but by approximations, or by tables, it has proved to be remarkably simple. We have tables of resistances given us, and obviously the first thing to do is to find the value of the L—the self-induction of the particular length of circuit under consideration. The expression for the inductance per unit length of two parallel wires is given by Clerk Maxwell in its most general form, which, when reduced, becomes

$$\frac{L}{l}=\left\{2\,\mu_0 \log_e \frac{b^2}{a_1 a_1'}+\tfrac{1}{2}\mu\right\} \text{ centimetres,}$$

where l = length of circuit in centimetres—*i.e.*, half the

* Contributed to the Physical Society of Glasgow University.

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length of wire—b = distance apart of wires between centres, a_1 and a_1' are the radii of the two wires, μ_0 the inductivity or permeability of the medium, μ the permeability of the material of conductor. For air, $\mu_0 = 1$, and for copper $\mu = 1$; and if the two radii, a_1 and a_1', be equal, the equation reduces to

$$\frac{L}{l} = 4 \log_e \frac{d}{a} + 0{\cdot}5.$$

If the distance of conductors between centres be approximately constant, it is advisable to calculate beforehand the self-induction per unit length of circuit for all the different sizes of wires to be used, or, better still, calculate $\frac{L}{l}$ for two or three sizes of conductors, plot and draw a curve from which to obtain all intermediate values.

I have plotted such a curve in Fig. I. for a distance between centres of 6in.; the abscissæ correspond to the cross-sectional area of the parallel wires, and the ordinates are the self-induction of unit length of circuit in centimetres.

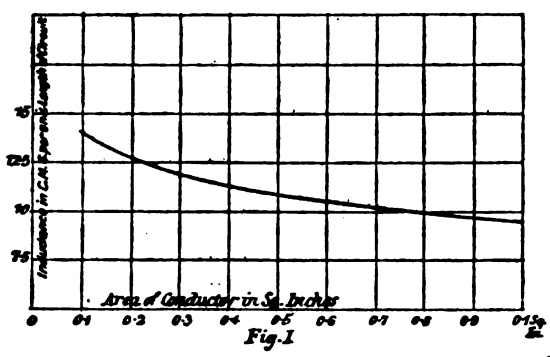

Fig. I

In general, what we require is the "drop" at the end of a line of which the length, resistance, self-induction, and potential at source is known, shown diagrammatically in Fig. II. A is the source at which the potential V_0 is known, l the length of each line of resistance and inductance, R/2 and L/2. The load consists of an impedance $(R_1 + ipL_1)$ in parallel with an admittance $(K + ipC)$. The resultant impedance at the end of the line

$$= \frac{1}{(K + ipC) + \dfrac{1}{R_1 + ipL_1}}$$

which can be reduced to the form

$$\frac{R_1 + ipL_1}{A + iB + 1}; \qquad \text{where } A = (KR_1 - p^2 CL_1)$$
$$B = (pKL_1 + pCR_1).$$

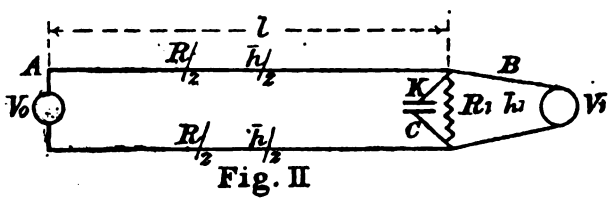

Fig. II

If I be the main current passing through as measured by an ammeter, the potential V_1 as measured by a voltmeter will be

$$V_1 = I\left\{\frac{(R_1 + ipL_1)}{A + iB}\right\},$$

and

$$V_0 = I\left\{(R + ipL) + \frac{R_1 + ipL_1}{A + iB}\right\},$$

which reduces to the form

$$V_0 = I\left\{\frac{A' + iB'}{A + iB}\right\}.$$

Practically, this problem is immensely simplified, as the load, being a lamp load, is non-inductive, and the capacity effect is negligible, the impedance of the load is reduced to R_1 simply, and $V_1 = IR_1$,

and

$$V_0 = I\{(R + ipL) + R_1\};$$
$$= I\{(R + R_1) + ipL\}.$$

The "drop"

$$V_0 - V_1 = I[(R + R_1) + ipL] - IR_1.$$

This is then the condition obtainable in a distributing network. In the expression $I[(R + R_1) + ipL]$, R_1 is the only unknown quantity, which can be easily obtained from the polar equivalent $x(\cos\theta + i\sin\theta)$, the modulus x we know to be $\frac{V_0}{I}$, and we have

$$[(R + R_1) + ipL] = \frac{V_0}{I}(\cos\theta + i\sin\theta).$$

Thus, if $V_0 = 100$ volts and $I = 200$ amperes by the measuring instruments—

$$\frac{V_0}{I} = \tfrac{1}{2}; \quad \tfrac{1}{2}\sin\theta = pL; \quad \sin\theta = 2pL,$$

from which θ is obtained, and therefore $\cos\theta$; then

$$\tfrac{1}{2}\cos\theta = R + R_1,$$

which gives us R_1, and finally $V_1 = IR_1$.

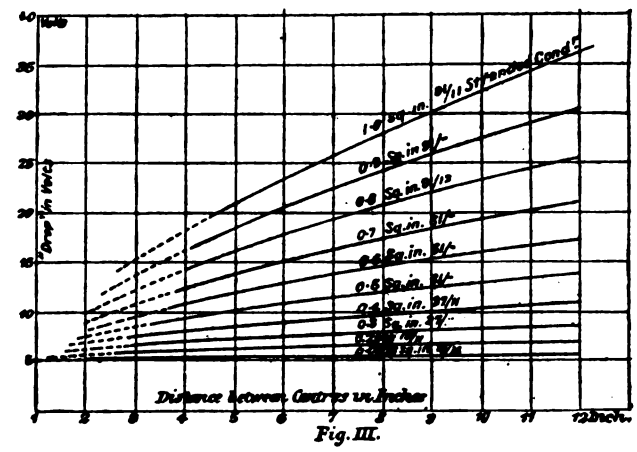

Fig. III.

This can be done at each successive step in the network design, but obviously the more practical way is to obtain an empirical expression, or, given a nearly constant distance between centres, to plot a series of curves from which the resultant "drop" of impedance and resistance can be read off at a glance. Curves, Fig. III., are plotted in accordance with the foregoing principles, and show how the drop varies with different distances between centres. The abscissæ represent distances from centre to centre in inches. The ordinates show the drop in volts under the following conditions. The length of the circuit is 100 yards. The potential at the source is 100 volts. The current in each case is that which gives 1,000 amperes per square inch, and is a mere convention. The lines start from a distance between centres at which the conductors would touch, and are drawn dotted up to a point at which their insulations would touch if covered. The inductance for this length is calculated from

$$L = 100 \times 91{\cdot}44\left(4\log_e\frac{d}{a} + 0{\cdot}5\right) \text{ centimetres.}$$

$$= 100 \times 91{\cdot}44\left(4\log_e\frac{d}{a} + 0{\cdot}5\right) \times 10^9 \text{ secohms.}$$

The resistance is that given in the manufacturer's tables for the corresponding sizes of stranded conductors, but corrected for non-equal distribution of current. Using Lord Rayleigh's formula,

$$R = R_0\left(1 + \tfrac{1}{2}\frac{p^2 l^2 \mu^2}{R_0^2} - \frac{1}{180}\frac{p^4 l^4 \mu^2}{R^4} + \text{etc.}\right);$$

where R_0 is the ordinary resistance for symmetrical distribution of current, l = length of conductor, μ = specific resistance of conductor, $p = 2\pi n$. If $n = 100$ ⌒⌣ per second, and a = radius of conductor, the equation reduces to $R = R_0(1 + \cdot 12\,a^4)$ for a copper conductor. Throughout the paper, the potential at source = 100 volts, which I specify, as the "drop" will vary with the potential for the same length and properties of circuit; also, $p = 2\pi n$, where $n = 100$ ⌒⌣ per second.

Suppose the distance between two parallel conductors of 0·5 cross-sectional area is 6in., we obtain, from Fig. III., for this a "drop" of 10·75 volts at the end of a circuit, each line of which is 100 yards, the potential at the source 100 volts, the load non-inductive, a current

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of 500 amperes passing through, and $n = 100 \sim$ per second. Now having fixed upon a distance between centres, the "drop" will of course vary with the length of the circuit and with the current passing through. Fig. IV. shows the "drop" for varying length and constant current.

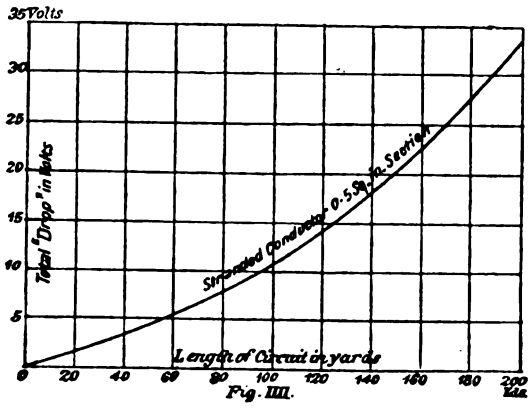

Fig. III.

The abscissæ show length of circuit in yards, and the ordinates the corresponding "drop" in volts, the conductor is a 0·5 stranded cable, current 500 amperes, potential at source = 100 volts, and alternations = 100 per second. Fig. V. shows how the "drop" varies with the current for the same length of circuit; the conductor is again 0·5 square inch section, the length of circuit = 100 yards. The abscissæ show current in amperes, and the ordinates the "drop" in volts.

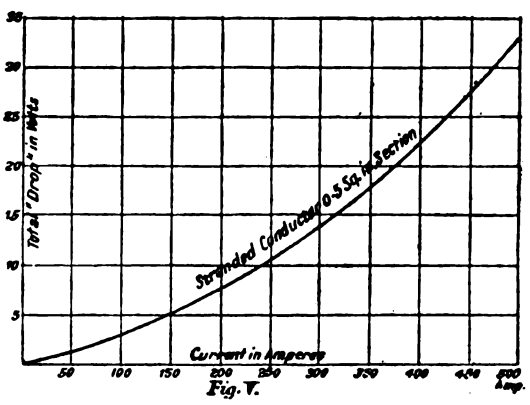

Fig. V.

150 yards, 100 yards, and 50 yards are a series of curves showing the drop for different current densities from 1,000 per square inch down to zero, and marked 0·9, 0·8, 0·7, etc., 1,000 per square inch being unity. Thus, suppose the circuit is 150 yards long, and formed of copper 0·5 square inch section with 6in. between centres, and suppose 200 amperes carried through; on the 0·5 curve at 150 yards for a current density of 1,000 per square inch we read 20·15. Following this curve for varying currents from the point until we come to ·4, which corresponds to 200 amperes on the 0·5 square inch cable, we read 5·19 volts, which is the "drop" obtainable. The resistance "drop" is $\frac{\cdot 05 \times 300 \times 200}{1{,}000} = 3{\cdot}0$ volts, where ·05 = resistance per 1,000 yards as given

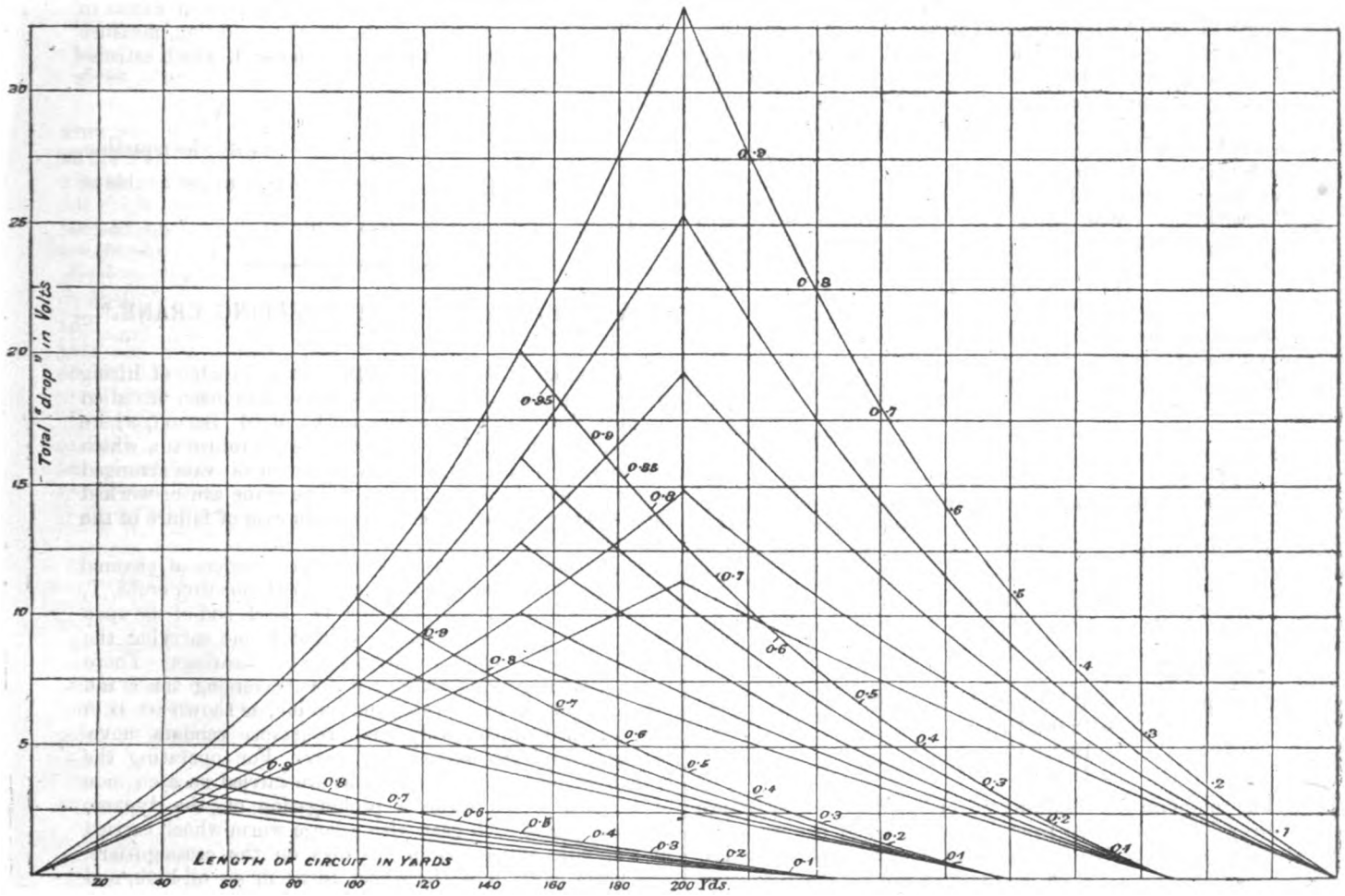

FIG. VI.

The next step to take in order to obtain convenience and despatch in marking a network is to combine the curves of Fig. IV. and Fig. V. for the sizes most generally used. I have plotted such a series in Fig. VI. for the sizes indicated. I have assumed a constant distance between centres of 6·in. and a potential of 100 volts at the source. Starting from the left-hand corner are curves for the sizes indicated showing the "drop" for all lengths of circuit up to 200 yards, and for a current density of 1,000 per square inch. Starting from the values of the ordinates at 200 yards, in the manufacturers' tables for a stranded conductor 0·5 square inch section. To this add 14 per cent. due to an increase of resistance for unequal distribution of current for this size, and 100 alternations from Lord Rayleigh's reduced equation, $R = R_0 (1 + \cdot 12\, a^4)$, which brings the resistance "drop" to 3·4 volts.* The difference between this and

* I am much indebted to Mr. Nisbett, of the City of London Electric Lighting Company, for the use of a table of virtual resistances for 100 $\sim$ per second for all sizes of conductors in general use, compiled by him from a formula given by Lord

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5·19 is the increase due to self-induction—*i.e.*, about 50 per cent.

Strictly speaking, it is not correct to apply the values obtained from these curves to a network, as they are particular values for 100 volts at the source end of the line, but they are quite accurate enough for the range of two or three volts on each side of 100 volts, which is a condition obtainable in networks, and a good deal more approximate than the estimated demand. I have only drawn the curves for varying current for four lengths—*i.e.*, 50 yards, 100 yards, 150 yards, and 200 yards—in order not to complicate the diagram, my object being to show the principle; in practice it is advisable to draw the current variation curves every 20 yards; all intermediate values can be got at a glance by interpolation. The above method works very well for one fixed set of conditions, and I can thoroughly recommend it; it is worth the few hours' labour and saves time.

Everybody dealing with alternating current should possess a table or a curve of self-induction per centimetre such as Fig. I., or, better, a set of curves of $\frac{L}{l}$ with varying distances between centres for the different sizes of conductors; such a table is quite general. Then if he has to deal with network, he should construct a set of curves such as Fig. III., which is limited to a particular condition of his practice, such as the periodicity and the potential at the source, either 400, 200, or 100 volts, as the case may be. As a matter of convenience, in order to be independent of tables of sines and cosines if not convenient, it struck me to try and obtain an empirical expression which would give the desired figure for any length of circuit and any current density. An expression of the form $a + bx$ was found to be very approximate for all distances within the limits laid down in this paper, and probably approximate enough up to 500 yards of circuit—*i.e.*, two lines 500 yards each—in which the drop due to self-induction is separated from that due to resistance, such that a is the ohmic drop, to which, in order to get the real drop for an incandescent lamp load and 100 alternations, but with any potential, it was only necessary to add a quantity bx, the expression is:

$$D\left(\frac{l}{100}\right) + (D' - D)\left(\frac{l}{100}\right)^2,$$

where D is the resistance drop for 100 yards of length of circuit and current density of 1,000 per square inch, l is the length of the circuit, D′ is the actual resultant drop for 100 yards of circuit as obtained on the curves of Fig. III. For example, let the cable be 0·6 square inch stranded, the resistance per 100 yards from manufacturer's list = ·004 ohm, the virtual resistance after correcting for skin effect = ·005 ohm; for 1,000 per square inch current density the "drop" = ·005 × 2 × 600 = 6·0 volts = D; for 100 ⌒⌣ per second 100 volts at the source end of the line for 4in. between centres, and for 100 yards length of circuit. Fig. III. gives 10·75 volts = D′.

Suppose the resultant drop is required for 200 yards, we have $\frac{l}{100} = \frac{200}{100} = 2$,

and drop $= (6{\cdot}0 \times 2) + (10{\cdot}75 - 6{\cdot}0) \times 4,$
$= 12{\cdot}0 + 4{\cdot}75 \times 4,$
$= 12{\cdot}0 + 19,$
$= 31$ volts.

Thus to obtain the resultant "drop," add to the resistance "drop" 12·0, obtained from data supplied by the manufacturers, a quantity, 19, obtained from such a table as Fig. III. depending upon potential and periodicity of the particular circuit. In this case the resultant drop is two and a half times the resistance drop. For any current other than 600 amperes a similar formula applies, and can be combined with the above by introducing another factor depending on the current density. The combined formula is $D\frac{l}{100} \times r + (D' - D)\left(\frac{l}{100}\right)^2 \times r^2$, where r = ratio of actual current to that which gives 1,000 per square inch. Thus, suppose for the same cable the "drop" for 300 amperes is required, this is half of the 600 for which the curve for 0·6 square inch conductor in Fig. III. is drawn out. If the other data are the same, we have for the "drop" on ·6 square inch cable 200 yards length of circuit, 6in. between centres, non-inductive load, and 100 volts potential at source—

$$D = 6{\cdot}0\ ;\ D' = 10{\cdot}75\ ;\ D - D' = 4{\cdot}75$$

"Drop" $= 6 \times 2 \times \frac{1}{2} + 4{\cdot}75 \times 4 \times \frac{1}{4},$
$= 6 + 4{\cdot}75,$
$= 10{\cdot}75$ volts.

If the current is 200, $r = \frac{200}{600} = \frac{1}{3}$,

"drop" $= (6 \times 2 \times \frac{1}{3}) + (4{\cdot}75 \times 4 \times \frac{1}{9},)$
$= 4 + 2{\cdot}1,$
$= 6{\cdot}1$ volts.

Perhaps a better way would be to obtain a table, or a curves like those of Fig. III., for a one yard circuit and 100 amperes, instead of a 100 yards circuit and 1,000 per square inch current density. In any case the above illustrates the principle, as the formula would be similar.

All the values obtained are only on condition that the permeability or inductivity of the medium is unity, and do not apply if the cables are laid apart in an iron culvert or in an iron-sheathed casing of any form. Much less does it apply to a case of the two cables being laid in two iron pipes; indeed, this last condition is absolutely prohibitive for electric lighting by alternating current (for iron pipes concentric cables must be used) where for a 0·5 square inch cable and 100 yards circuit, the extra drop would not probably be more than $\frac{1}{8}$ per cent. Any form of sheathed casing is bad; but to obtain the value of L, a plan which works very well is to lay a pair of cables in the culvert or casing under the actual condition, measure the potential at both ends, find a value of L which satisfies the equation

$$I\{(R \times R_1) + i\,p\,L\} - I\,R_1 = V_0 - V_1,$$

and find such a value of μ_0 as will satisfy the equation $L = l\,(\cdot 4\,\mu_0 \log \frac{d}{a} + 0{\cdot}5)$, and use this value to get a table of L/l for the different conductors in use.

Kelvin in his presidential address to the Institution of Electrical Engineers, and known as the ber, bei formula.

OVERHEAD ELECTRIC TRAVELLING CRANE.*

An overhead electric travelling crane, capable of lifting weights up to a maximum of 10cwt., has been installed by MM. Julien et Cie. in the works of M. Bertou, where it is employed in handling heavy cages of refuse tin, which are treated by being dipped in a number of vats arranged along the length of the factory. The crane can be worked mechanically as well as electrically in case of failure of the current.

The framework consists of two cross girders of channel iron section, carrying a couple of geared hoisting crabs, T, between which is placed a motor, D. Each end of the span rests upon and is bolted to a light frame carrying the traverse wheels, which are fitted with ball bearings. There is no power gearing employed for traversing the crane except a simple hand rope and pulley, as shown at B in Fig. 1; the comparatively small resistance renders movements to and fro exceedingly easy. For operating the crab hoisting barrels, steel worms are carried on each side of a shaft, which forms a prolongation of the dynamo spindle. These each gear with a large worm-wheel, carried by a spindle supported in bearings on the cross girders. The lower portion of the wheel turns in an oil-bath, and upon its extended axle is a collar, over which the lifting chain passes. At one end of the long dynamo, or main driving, shaft is a grooved wheel, A, round which may be passed a rope for lifting by hand should the current fail at any time.

The motor is of the Rechniewski type, constructed by the Société de l'Eclairage Electrique. When under normal load, it requires 15 amperes at a speed of 1,800 revolutions per minute, the pressure employed being 110 volts. The main leads from the source of supply to the motor are con-

* Abstracted from the *Revue Industrielle*.

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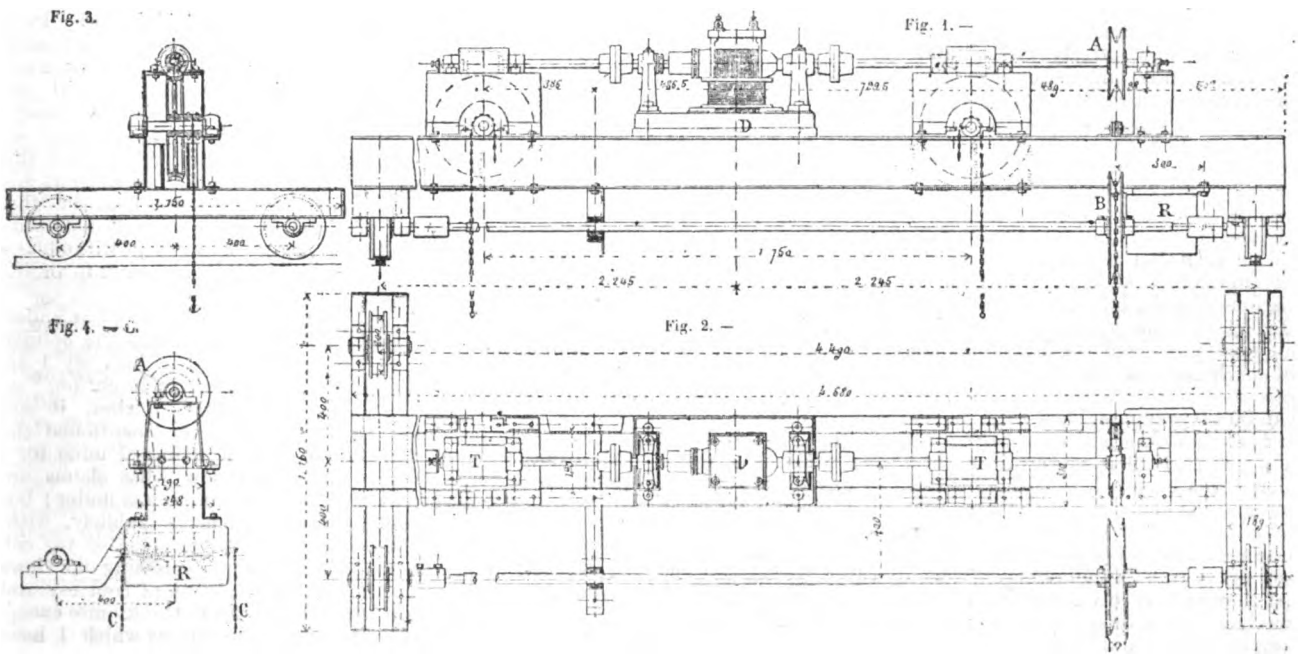
nected to resistances, R, beneath the crane frame, and, in addition, two switches are provided for changing the direction of the current as it is desired to lift or lower away. Starting and stopping are effectuated by means of graduated resistances, which are brought into play by the cords, C (Fig. 4). The ends of these cords are carried to the switch handles, and with a pull one way or the other motion can be given or arrested.



Overhead Electric Travelling Crane.

INSTITUTION OF ELECTRICAL ENGINEERS, Mar. 8.

Mr. ALEX. SIEMENS, President, in the chair.

At last night's meeting of the Institution the following candidates were balloted for:

Members.—Sidney Howard Farrar, Johannesburg, and 69, Cornhill, London; William Claude Hill, European Works, Pownall-road, Dalston.

Associates—Arthur Hinton Allen, Central Institution, Exhibition-road, S.W.; John Edward Dane, 20, Alexandra-road, Selhurst, S.E.; F. R. Davenport, 1, Granville-road, Eastbourne; James Livsey Dyson, 18, Earlham-grove, Forest Gate; John Charles Dwyer, care of Messrs. Grindlay and Co., 55, Parliament-street, S.W.; John R. Gall, the National Telephone Company, Oxford-court, Cannon-street, E.C.; Cecil W. Gwyther, Godstall-chambers, Chester; Owen M. Jonas, 38, Grainger-street West, Newcastle-on-Tyne; Enrique W. Martin, Valparaiso, Chili, and 191, Richmond-road, Hackney; Joseph Horsnell May, 3, Vincent-terrace, N.; Alexander Moir, Engineer's Department, Postal Telegraphs, Leeds; Edward B. Pym, Bar-chambers, Scarborough; J. Clifton Robinson, Managing Director, Imperial Tramways Company, Clare-street House, Bristol; Sherley Sherley-Price, 49, Queen Victoria-street, E.C.; Dudley Stuart, The National Telephone Company, Oxford-court, Cannon-street, E.C.

Students.—Frederick W. Dalton, Seagrove Rectory, Loughborough; Edmund J. Fox, University College, Nottingham; William James Grey, 7, Hill-street, Rutland Gate, S.W.; Percy George Rathbone, Faraday House, Charing Cross-road, W.C.; Ernest Sherley-Price, 49, Queen Victoria-street, E.C.; R. E. Skipwith, Long-row, Nottingham; William Frederick Stuart-Menteth, 48, Chaucer-road, Bedford; Charles F. Wilkin, 8, Wolseley-gardens, Chiswick.

The following paper was then read:

ON PARALLEL WORKING, WITH SPECIAL REFERENCE TO LONG LINES.

BY W. M. MORDEY, MEMBER.

In his reply at the end of the discussion on his Niagara paper, Prof. Forbes alluded to some experiments which he had witnessed, and which he considered showed that alternators of my design would not run properly in parallel. The passage is as follows: "At the time when I recommended the Mordey machine I said that, before deciding to adopt it, tests must be made with a resistance between the dynamos in parallel. Does Mr. Mordey forget that, when he kindly placed at my disposal the means of making this test, by putting 'sunbeam' lamps in series—that is to say, between the two dynamos working in parallel—the lamps went up and down in brightness with the periodicity of a few seconds, and that the tendency was to rise to maximum brilliancy, showing that the dynamos were rather working in series than in parallel? From the moment of those experiments, I felt that that type of machine was not suited for our purposes, though I never mentioned that until I was compelled to by Mr. Mordey's claims for his special mode of working." I heard his remarks with the utmost astonishment, as the experiments, rightly interpreted, appeared to afford the very strongest proof of the exceedingly powerful synchronising effort exerted by these machines, and because I then heard a contrary view expressed for the first time. And in another passage Prof. Forbes stated that they must have alternators at Niagara that will run without any synchronising or waste current.

The matter is of some moment, and demands an explanation. With your permission, I will make this explanation the text and starting point of a paper on parallel working, and on the allied subject of the use of alternators as synchronous motors. The experiments were made in July, 1891, and were mentioned in the *Electrical Review* and elsewhere, in each case as having afforded an illustration of the thoroughly satisfactory parallel working of alternators when directly coupled to high-speed engines—a matter with regard to which there was at that time some uncertainty. It had been supposed that some flexible or yielding coupling was necessary between the engine and alternator. For my own part, I never had any doubt on the subject; but in order to place the matter beyond dispute, some tests were carried out by the Brush Electrical Engineering Company and Messrs. Willans and Robinson. The former provided two of my alternators, the latter fitted them to two Willans engines. Amongst others, Prof. Forbes received an invitation to witness the trial, and was present.

When all the tests of ordinary parallel working had been satisfactorily carried out—including shutting the steam off the engine driving one of the alternators, and then applying a brake to its flywheel in a vain attempt to force it out of step—a further test was made (as an interesting experiment bearing on the subject of synchronous motors) to ascertain what would occur if the two alternators were coupled together with a resistance between them so great that the resistance alone would be sufficient to absorb the whole power of one machine, even if the machine at the other end were at rest; and the remarkable fact was established that even under these conditions (which would be absolutely absurd or impossible in practice) the two machines did not break out of step. The resistance used consisted of "sunbeam" lamps, which happened to be the only suitable resistance available. These lamps, being made for 80 volts and about five amperes, would have a resistance, hot, of about 20 ohms each, and a much higher resistance when cold—probably more than 30 ohms. Seven of these lamps were placed in series between the alternators. There was no other external circuit. It was then found that there was a current passing through them which rose and fell with a slow pulsation; the alternators, although not actually breaking out of step, evidently getting a good deal out of true co-phasal synchronism, and only being pulled in when this slowly pulsating current rose to a considerable amount. Synchronism being regained, the current decreased again. This current was not measured, but was probably about seven amperes, as the lamps were a good deal over-incandesced. The experiment was then discontinued. Properly interpreted, this test appeared to show that even when a line of an enor-

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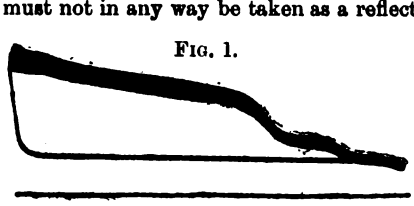
mously high resistance was interposed between two alternators arranged to run in parallel (or one as generator, the other as synchronous motor), and when no adjustments were made to help them to keep together, the tendency to get out of step was corrected with a surprising amount of success. The correction, instead of being instantaneous and powerful, as with machines connected through a small resistance only, being sluggish, and greatly weakened by the effect of the very high resistance of the line.

To show how utterly unfair and unjust Prof. Forbes's interpretation is, and to reassure those who may desire to use synchronous motors, it is only necessary briefly to examine the conditions of the test. The two alternators used in the experiment were 37·5-kilowatt 2,000-volt machines. At full load each would therefore give nearly 20 amperes. Now, suppose it is desired to run one machine as a generator, driving the other as a synchronous motor (to take the illustration that may best suit the case of power transmission over a considerable distance), it will be seen that if the line is to be designed to give such a percentage loss as is proposed for the Niagara-Buffalo transmission—that is, 3·5 per cent.—the loss at full load should be 70 volts, and the maximum current being, say, 20 amperes, the line resistance should be 3·5 ohms. In the actual experiment, the machines did not break out of step even when the line resistance was more than 100 ohms—that is, relatively more than 30 times greater than Prof. Forbes proposes to use even for his long-distance transmission. This is the more striking as a proof of their powerful synchronising when it is considered that even if it had been intended to expend the whole power of the generator in the line, that line should only have had a resistance of 100 ohms. That these machines did not act quite perfectly in parallel under these conditions, even with no load, is not to be wondered at. The only cause for surprise is that they exerted any sensible synchronising effort at all. It is exactly as if an attempt had been made to run two 1,200-kilowatt alternators in parallel through a line constructed to allow a reasonable loss for a couple of 40-kilowatt machines. Even unloaded such a test would be unreasonable.

I now wish to refer to the "hunting" or regular pulsation of current, shown by the slow changing of the lamps from blackness to high incandescence, which is a matter of considerable interest. It may have been caused by self-induction, or, as, in this connection, it is sometimes termed, armature reaction—that is, the effect of the self-induced field produced by the armature in disturbing the impressed field of the field magnet. Although this effect may in some cases be considerable, I think we must look elsewhere for it in this case, because in the machines in question such reaction would have been inconsiderable, even if the phase relation had been most favourable to it. This I may illustrate by saying that if the armature current had been commuted, and passed round coils on the field poles having turns equal in number to the armature coils, the effect on the field would have been inconsiderable. I think an explanation of the "hunting" will be found in the character of the resistance and in the governors of the engines. The change in the resistance of the lamps accounts largely for the pulsation. When black they would interpose a very high resistance—probably about 200 ohms—then, as the machines got a little out of step, the synchronising current would heat them, reduce their resistance, allow a much readier transfer of power, and so bring about a restoration of true synchronism and a reduction of current through the lamps. This series of effects, being constantly repeated, goes a good way towards explaining the pulsation. Probably without this lowering of the resistance by the incandescing of the lamps, synchronism would not have been maintained at all.

Then, again, the governors of the engines must be considered. If they pulsated with the same period, but opposite phase, the action is explained; they would, at any rate, accentuate the "hunting," if they did not start it. Messrs. Willans and Robinson have kindly sent me an indicator card, taken by Mr. Willans at the time, which supports this view, the steam being shown as having been widely varied during the taking of the card. This must not in any way be taken as a reflection on the

Fig. 1.



governors. The conditions were very trying for any governors, there being no load, and no opportunity occurred of specially adjusting them. If we had governed by hand at the stop valve, this "hunting" would not have occurred. Nor would it have occurred if we had adjusted the E.M.F. of one machine so as to allow it to run as a motor all the time. What happened appeared to be a repeated change in the functions of the two machines, from generator to motor—first one racing, and then the other, driving the second one as a motor.

The condition of entire absence of synchronising current or of correction can only be obtained by driving by engines that are very even in power always. I think this is more likely to be approached by turbines than by reciprocating engines. By "synchronising current" I do not mean necessarily an actual current passing from one alternator to the other—this only occurs when one of them is driven as a motor—I mean the variations of the current contributed by each machine to the circuit. But I would like to point out that the condition laid down by Prof. Forbes as an essential—namely, that they must have alternators at Niagara that will run without any synchronising or waste current—is an absolute impossibility. Alternators will run without synchronising current only when there is no necessity for them to exert any synchronising effort. However, I am glad to find that Prof. Forbes has set himself to solve this problem of getting an alternator motor to run without any current (for that is what it amounts to), because I am sure that in solving it he will also have disposed for ever of that other interesting problem—making a motor that will run without any back E.M.F. This is a new and significant outcrop of the "perpetual motion" idea.

I am sure that if Prof. Forbes had really considered or understood this matter he would not have expressed the opinion which I have quoted. At the same time, I wish to say I am convinced that his criticism was not unfair by intention. At the end of the passage quoted from Prof. Forbes, it will be seen that he states that he had never mentioned the matter until compelled to do so by some claims of mine for a special mode of working. I do not know what claims are referred to, nor do I know what compulsion he was under; but I do know that in making these statements publicly, without first mentioning the matter to me or to some of my colleagues and giving us an opportunity of expressing our views or giving an explanation, he exhibited a want of courtesy and of ordinary consideration which I venture to think quite exceptional. In the frequent friendly conversations which I have had with him there have been ample opportunities for the discussion of such matters. No doubt he had a right to advise his company as he thought proper; but I maintain that, without the very fullest justification for his statements, he had not a right to come to this Institution and, in the most public manner, utter charges seriously affecting the character and capabilities of a trading company's manufactures. I submit that in his strictures on the synchronising power of my alternators he was absolutely without such justification.

The necessity for correcting a false impression has forced me to take the first opportunity of bringing this matter before the Institution. I regret that Prof. Forbes is abroad, but he will of course have an opportunity of sending on for the *Journal* any observations he may wish to make. It was not my intention to do more than make the above explanation, feeling sure that it would be sufficient to enable the Institution to form a correct judgment on the circumstances; but as I am permitted to occupy more of your time than I expected, I wish to refer to some tests that I have been able to make. It appeared desirable to give the results of actual trials, preferably working one machine as a synchronous motor, and not merely as one of a pair of parallel connected generators. It will be granted that the action of synchronous motors and of parallel alternators is very similar. But with regard to the trials just referred to, it might fairly be argued that as each alternator had a steam-engine behind it, on which it could fall back for assistance, something more is wanted to actually prove that the explanation is applicable to the case of a synchronous motor relying entirely on its own motor properties. I am, therefore, glad to be able to place before you the results of some tests made in the works of the Brush Company.

Some Tests of a 25-Kilowatt Mordey-Victoria Alternator used as a Motor.

This test was carried out by my instructions on February 18, 1891, four months before that witnessed by Prof. Forbes. A 2,000-volt 25-kilowatt alternator was run as a motor, driven by a 37·5-kilowatt generator. The motor drove a dynamo which was loaded until the alternator motor was taking about its full normal current, it being assumed that this represented full power. Separate tests have proved this assumption to be justified. The following readings were taken with a resistance of straight platinoid wire between the machines:

Test A.

Volts. Generator terminals.	Volts. Motor terminals.	Amperes.	Resistance in line. Ohms.
2,340	2,002	13·74	32
2,358	1,932	13	48

The volts of the generator were raised above the motor volts sufficient to supply approximately the line loss. This test was quite satisfactory, and, of course, settled, so far as we were concerned, any question that might at any time arise as to power transmission over long lines by synchronous motors—a matter that was from time to time coming up in connection with proposed installations. As a result, I always considered it quite safe to quote for work up to a line loss of

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20 per cent. But my attention being recalled to the subject by the extraordinary statements of Prof. Forbes, I took the opportunity, after writing the foregoing explanation, to make some tests having a particular bearing on the details of the question before us. In some respects they are rather wanting in completeness—I was not always able to carry them as far as I wished—but I feel sure that you will approve of my supplementing my explanation by an account of such tests as the facilities at my disposal at the moment rendered possible.

TESTS OF 50-KILOWATT ALTERNATOR AS A MOTOR.

The object of these tests was to ascertain the effect of inserting resistance between two alternators, one of which ran without load as a synchronous motor. It was desired to find—(*a*) what resistance was required to cause the motor to fall out of step; (*b*) how much the current varied, and how it varied; and (*c*) whether any "hunting," or pulsation, was set up. Two similar 2,000-volt 50-kilowatt alternators were used.

Generator.—This was driven by a separate engine capable of working it up to full load. It was run without governor, and controlled by hand at the throttle-valve.

Motor.—This was started and brought up to synchronism by a small direct-current motor, driving by a belt which was thrown off as soon as the large motor was running synchronously. The two machines were excited from a separate dynamo, their fields being in parallel. The E.M.F. at the generator terminals was measured, and the current from armature to armature. The field currents were not measured, nor the E.M.F. at the motor terminals. The generator was excited to give 2,000 volts, and then the motor field was adjusted till the current received by the armature was a minimum. This will be understood from Fig. 2, which is reproduced from a paper on

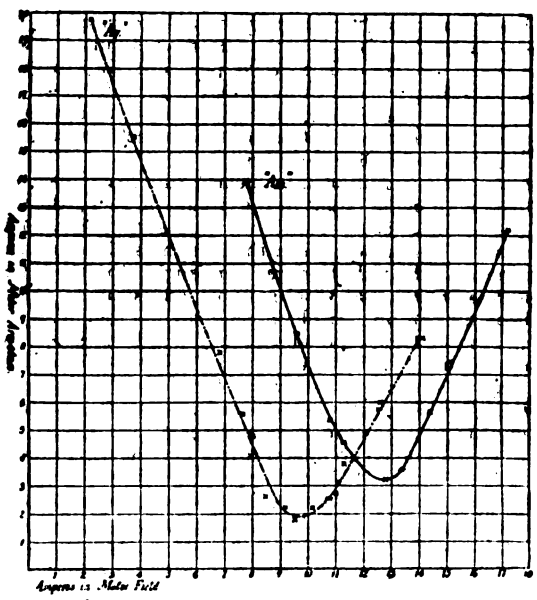

FIG. 2.

"Testing and Working Alternators" I had the honour of reading before this Institution last year. It may be remembered that I showed that there is a well-marked excitation that reduces the armature current to a minimum for any given load, and therefore gives a maximum power factor and maximum efficiency. If the excitation be varied on either side of that value, the armature current taken by the motor rapidly increases. In working a motor it is desirable always to adjust the excitation till the bottom of this V-curve is reached—that is to say, until the armature current is a minimum. In the case before us this current was found to be 1·6 amperes. Having got this, the excitation was not disturbed, and the following readings were taken:

Test B.

Volts at generator terminals.	Current.	Resistance in external circuit between generator and motor.	Remarks.
2,090	1·6	0	Current steady.
,,	1·6	10	,,
,,	1·6	20	,,
,,	1·7	35	,,
,,	3·5	63	,,
,,	3·6	69	Current rather unsteady.
,,	5 3	77	,,
,,	—	90	Current increased rapidly at this point, and the motor slipped quietly out of step.

In the first place, it is to be noted that there was no "hunting," or pulsation. The unsteadiness of the current was not regular. Examining this test with a view to its practical aspects, it will be seen that it fully supports the explanation given at the commencement. Applying to it a similar comparison, we see that, as the alternators were 2,000-volt 50-kilowatt machines, a line proper to these, in order to comply with the Niagara-Buffalo condition of allowing a loss of 3·5 per cent. in transmission, should have a resistance of

$$\frac{2{,}000 \times 3{\cdot}5}{25 \times 100} = 2{\cdot}8\ \omega;$$

and that the resistance of external circuit that would be sufficient to dispose of the whole load of the generator, supposing it to be merely working on that resistance as a load, would be

$$\frac{2{,}000}{25} = 80\ \omega.$$

Exactly as in the case of the trial witnessed by Prof. Forbes, we find that a resistance of about 30 times a reasonable working amount had to be inserted before synchronism was interfered with, and it will be observed that more than 20 ohms had to be inserted before any effect appeared to be produced. But it may be said that the line loss, even with this enormous resistance, is comparatively trifling, as the current is not large, and that there ought to be plenty of power left to keep the motor in step. There is plenty of power, but it cannot be applied to the motor advantageously. The line loss, even with 5·3 amperes and 77 ohms, is only 408 volts and 2,156 watts (I am considering only resistance and current), whereas the generator was capable of supplying 50,000 watts. But it must be remembered that, the E.M.F. of the motor being kept up, it can only receive current under these conditions by letting itself get partly out of phase (and so into a disadvantageous position), and that then every increase of current intensifies the evil by causing a further loss of volts on the line, and therefore a further reduction in the E.M.F. impressed on the motor. How I lowered the E.M.F. of the motor, or increased the E.M.F. of the generator, the line resistance could have been still

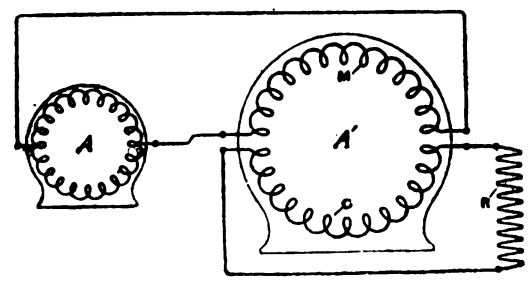

FIG. 3.

further increased without loss of synchronism. Such a change of the relative E.M.F.'s of the motor and of the generator would have allowed current to get into the motor against the lower ordinates of its E.M.F. waves, without the necessity for any serious shifting of phase. If the motor E.M.F. had been lowered in this way the driving current would have increased, and synchronism would have been maintained much longer and through a higher line resistance, and would finally have been lost by the power being wasted in the line, and by "armature reaction" on a weakened field.

Or, again, if the excitation of the motor had been raised, it should be found that it would go out of step with a smaller external resistance than before. This matter is of practical importance, as perhaps others than Prof. Forbes may wish to work through a line 30 times too long, and therefore some tests were made to prove the truth of this explanation.

Test C.—The machines were run under the conditions of the fifth line of the readings given above—that is, with the excitation as before, and with an external resistance of 63 ohms, the current being 3·5 amperes. The excitation of the motor was then increased, probably about 20 per cent. Before there was time to take any reading the motor went out of step. This was satisfactory as proving the correctness of the explanation.

Test D.—Another test was made with the motor acting as a dynamotor in the manner shown in Fig. 3 (also reproduced from last year's paper). One half, M, of the armature winding was used as a motor; the other half, G, as a generator working on a separate circuit, R. In this instance a load of five amperes and 2,000 volts was put on this generator portion, the lowest armature current being obtained with an exciting current of about 11 amperes. The field of this dynamotor was then reduced from 11 to 6 amperes, but it did not show any signs of getting out of step. The driving current rose to 15 or 16 amperes. But on increasing the dynamotor field to 17 amperes it went out of step, the driving current being about 15 amperes. This test is not on all fours with the other, as there is the effect to be considered of the varying load on G, but it is a confirmation in a general way of the explanation.

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Test E.—A test was then made to find, when working with no appreciable resistance between the machines, whether any "hunting," or pulsation, was set up by varying the excitation of the motor till the armature current rose considerably up either slope of the "V." On decreasing the excitation till the armature current rose from 1·6 to 6 amperes the current became rather unsteady or irregular; the motor evidently getting a little out of step sometimes, and being pulled in by slight rushes of current of very short duration, which probably over-corrected the irregularity, causing the machine to run for an instant without current, or to act as a generator and itself to give current—that is, to act as an electro-mechanical flywheel, converting mechanical to electrical energy, and *vice versâ*. On increasing the excitation again, passing the bottom of the "V," and rising up the opposite slope to the same height (about six amperes), it was found that the current was rather steadier than under the conditions last noted—that is, when the current was about six amperes it was rather more unsteady in a strong field than in a weak field. The explanation of this difference is that with a weak field the motor could receive current during its whole phase; whereas with a strengthened field the E.M.F. waves would be higher than those of the generator, and some want of co-phasal synchronism would be needed to allow current to get in. In neither case was there any "hunting" or regular pulsation of current.

Some Tests of a 25-Kilowatt Alternator used as a Motor.

The motor in this case was arranged to drive a direct-current motor by means of which a load could be put on it that would be quite constant so long as speed was constant. It was desired (*a*) to find the effect of placing in the alternator circuit various amounts of resistance; (*b*) to find the effect on the steadiness. The 25-kilowatt alternator motor was driven by a 50-kilowatt alternator as generator.

Test F.—Motor was run with no load except its own direct-coupled exciter, and the direct-current dynamo, which in this case was run unexcited.

Effect of Reducing Motor Excitation as Resistance in External Circuit was Increased.

A. Generator. Volts.	A. Motor. Volts.	Amperes.	Line resistance.	Remarks.
2,000	2,000	2·23	0	Current varying a little.
1,980	1,900	3·7	0	Current very steady.
2,040	1,900	3·5	65	,,
1,960	1,840	2·0	65	,,
1,950	1,820	2·23	75	,,
1,960	1,800	2·0	85	,,
1,960	1,780	2·23	95	,,
1,960	1,760	2·23	105	,,

We thus see a confirmation of what has been said about steady running being obtained, even with a very large resistance in the circuit, if there is a sufficient difference between volts of generator and motor. This is very common sense, and an experiment to prove it may seem superfluous. The experiment was not carried further, as the resistance used was the greatest available at the moment. This light-load test should be read in connection with the full-load test A.

Test G.—A test was then made with a load on the direct-current dynamo. This load was eight kilowatts, and was constant. Allowing for friction, and various losses outside of itself, the alternator motor was doing between 14 h.p. and 15 h.p.

A. Generator. Volts.	A. Motor. Volts.	Amperes.	Power developed, about h.p.	Resistance.	Remarks.
2,040	2,040	7·0	14·5	0	Current fairly steady.
2,040	1,980	7·3	,,	6	,,
2,060	2,000	7·45	,,	10	,,
2,040	1,900	8·2	,,	25	Current steadier.
2,040	1,740	9·8	,,	35	Current steady.
2,120	1,540	11·0	,,	45	,,

In this is seen the gradual increase of motor current as the motor volts get lower, while steadiness rather improves with the addition of length (or resistance) of line. The test is incomplete, because it was not convenient to put a larger load on, and therefore the motor was not worked up to full power; but it is confirmatory of test A. It is interesting to observe, with regard to this test, that the idle current was very small. For example, the first reading of seven amperes may be divided into 2·25 amperes needed to drive the motor and its exciter, and for friction of the direct-current dynamo (see test F); and into 4·75 amperes for the added load of eight kilowatts. The dynamo gave eight kilowatts, and the motor received about 4·75 amperes × 2,040 volts = 9,690 watts. Allowing for the losses in the two machines, it will be recognised that the transformation was not only very fairly efficient, but that the power factor was evidently high. The relative lowering of the E.M.F. of a synchronous motor is a necessity in order to obtain good results in power transmission over long distances. In this way the necessity for self-adjustment by the motor of the phase relation is avoided, the motor being enabled to work (other qualities permitting) at its most advantageous phase relation. And the other advantages are retained of high power factor (that is, a small idle current) and a high efficiency of generator, motor, and line. By this means it will be found possible to work such motors over very long lines, and with almost any desired line loss. It of course has its counterpart in direct-current power transmission, but there is a difference. In once case the speed varies and the field remains constant; in the other the speed remains constant and the field must be varied. It is not necessary to alter the excitation of a direct-current motor—its speed simply drops or rises until it has got the right E.M.F. With an alternate-current synchronous motor the speed cannot drop. The excitation must be lowered in this case to give the right E.M.F. Failing this, the motor will shift its phase in an endeavour to attain the same result. Of course in the direct-current machine the speed may be kept up by lowering the field.

Some Tests of Two 100-Kilowatt Alternators.

Test H.—By the kindness of the City of London Company, I was enabled to make a trial with two of their 100-kilowatt alternators at Bankside, with the object of finding if, under the ordinary conditions of the station, these machines would work parallel with a considerable resistance between them and their load. For this purpose a load of about 100 kilowatts was put on, and the two alternators were made to supply it through a resistance of 7·5 ohms in the external circuit of each. As this resistance corresponds to 37·5 per cent. line drop at full load, and 18·75 per cent. drop at half load, it is a fairly severe test. It was found that some lamps and a voltmeter placed across the load (a wire resistance) kept perfectly steady. This, of course, was only a half-load test.

Test J.—When full load, or nearly full load, was on both machines, with eight ohms in the circuit of each, there was a quite noticeable, but not at all violent, slow pulsation in the synchroniser lamp direct across the terminals of the alternators; but at the load the pulsation was very slight—barely noticeable. My impression was that with suitable adjustments this would have been quite a practicable arrangement—that is, to feed a lighting system from two alternators parallel, each having a 20 per cent. line loss between it and the load—a condition that is not likely to present itself very often.

Test K.—An attempt was then made to run the two machines parallel, with a load close to one of them, but separated from the other by a line of 16 ohms, corresponding to a line loss of about 40 per cent. The machines did not show any inclination to get out of step, but there was a pulsation of the E.M.F. at the lamps (at the load) of about 4 or 5 per cent. The result of this test, as carried out, was not good enough for lighting; although if time and facilities had allowed, I think it quite likely that it could have been made satisfactory; but there was no pulsation or unsteadiness of a kind that would have interfered in any way with power transmission work. It is a pleasure to me to make my acknowledgments to two assistants, Mr. Stobart and Mr. Foyster, who have ably aided me in connection with the recent tests and experiments, and to Mr. Watson in connection with the tests in 1891.

Some Analogies.

Probably I am not alone in having often found a difficulty in conveying to persons not specially familiar with alternate-current matters, any very clear idea of the kind of action that takes place in parallel working. I would like, therefore, to be allowed to conclude by describing an analogy which I have often found useful in such cases. Everybody knows something of toothed wheels. To explain the relations of two alternators, separately driven, working parallel, imagine two engines driving by spur gearing on to a common shaft. The shaft represents the circuit from which power may be taken; the spurs, or teeth, represent the successive waves of current. The operation of getting into synchronism is understood when one engine is imagined as running at its proper speed geared with the countershaft. To get the second engine to help, it will readily be understood that before being geared with the shaft it must be brought up to such a speed that the spurs of its toothed wheel synchronise with those on the shaft. A synchroniser, or phase-indicator, is the equivalent of a device for showing when the teeth of one wheel are exactly opposite the spaces between the teeth of the other wheel—that is, when they are synchronous. The mechanical process of slipping the two spur wheels together is the equivalent of electrically connecting the alternator and the circuit, and all the effects of doing this switching at the wrong time are easily illustrated by the sudden strain that would be imposed on the teeth. It will now be easy to follow the process of increasing the supply of steam to the engine until it transmits

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its proper proportion of power to the shaft; as well as the reduction of steam to such a point that the connection of either engine with the shaft (or of alternator with the circuit) can be interrupted at a time when no power is being transmitted from it or to it, and when, in consequence, its withdrawal makes no difference to the remaining engine (or alternator) or to the countershaft (or circuit). The changing of load from one engine to the other is readily understood. Then the difficulties of parallel running may be made clear. Imagine one engine to get an insufficient supply of steam: it will be seen how the other must not only keep the countershaft (and any load) going, but must also drive the other engine. And note that this driven engine (receiving its power from the countershaft) is the analogue of the synchronous motor, and that the fact that the pressure is now not on the front side, but on the rear side, of the teeth, corresponds to the pull on the poles and armature coils being in the opposite direction to what it was as a generator, and that the difference of phase, or angle, between a generator and a motor is illustrated by this change in the relative position of the teeth on spur wheel and shaft. If the teeth of one wheel are exactly midway between those of the other, corresponding to exact co-phasal synchronism, a line drawn through the tip of one bisects the hollow of the other, and driving is possible either way in this position only if there is absolute fit—that is, no lag or lead—no clearance either side. And this is not possible in practice. There is always a lead or a lag, corresponding to similar changes in the relative positions of field and armature in an alternator, as generator and as motor, this change of angle being also conveniently expressed or measured in terms of the space occupied by a pair of teeth or a complete period.

Then it is possible, by this analogy, to get an engine-builder to see what happens when an engine runs at different speeds during parts of each revolution. He will see that if two engines are in use, and one is slowing a little as it goes over its dead centres, while the other is getting steam and quickening a little, the teeth of the former will be bearing with diminished pressure on the teeth of the countershaft, while the latter will be exerting increased pressure. And he will see that, if this difference is considerable, the power may all have to be supplied by one engine, which may even have to drive the other engine as well—that, in short, each engine may in each revolution be alternately a generator and a motor, twice or oftener (according to the number and setting of the cranks). It will not be difficult to explain the pulsations of synchronising current transmitted through the circuit between the two alternators by the analogy of the impulses transmitted from one engine to another through the countershaft. He will also understand why, if the engines have this defect, this interchange of power will not take place, and will not be required, if he so arranges matters that the connection is made at a time when the engines (supposing them arranged to run at the same speed) are in the same part of their stroke; but in this case, as the engines cannot correct each other's irregularities, the speed of the countershaft may have an objectionable want of evenness of running, affecting any machinery driven from the countershaft—that this difference will be less on the driven machinery if it is driven by belting, and therefore not necessarily synchronous, than if it is driven by spur gearing, and so forced to run at the same speed.

I will not stop to do more than suggest the comparisons that may usefully be drawn between weight of flywheel and of electromagnetic inertia or self-induction as illustrating the effects in steadying the running of all shafts or circuits. But I cannot resist the temptation to show that, as with alternators in parallel the very rapid interchanges of power take place with scarcely perceptible resistance—that is, frictional—losses, it is conceivable that two such machines and engines will take less steam to drive them than if they are dividing the same load between them on separate circuits. That this increase in efficiency is a fact has been shown by actual tests, which I hope later on will be placed before you. Then the analogy may be carried further, and an understanding may be imparted of the difference in the synchronising abilities of various alternators. To do this it is necessary to add to the analogy of spur gearing the idea of that gearing having teeth of various degrees of stiffness or rigidity, varying all the way from phosphor bronze to yielding elastic material such as soft rubber. The former may be compared to the alternators having unyielding fields and small armature reaction; the latter to machines having poles the magnetism of which gives way, more or less, under pressure. It will, no doubt, be difficult to get the uninitiated to grasp the idea of a tuft of lines of magnetic force from a pole-piece acting, through air, on a copper wire carrying a current as corresponding to the material teeth of spur wheels geared together; but it is at least worth the attempt, and the result is usually better than the antecedent chaos.

Having conveyed this idea of various degrees of rigidity of teeth as the equivalent of the various degrees of synchronising efforts of which different alternators are capable, the next step is to explain why with alternators having magnetic teeth of the gelatinous variety it is possible to put them into parallel (or to gear them) when they are unsynchronous, without anything happening except a more or less complete temporary flattening of the teeth (or alternations) of both machines, corresponding to a temporary cessation of useful effort, until they have gradually worked themselves into phase. And it will be understood why with such machines any sudden alterations or strains should be avoided as likely to result in the bending down of the teeth, and loss of synchronism. On the other hand, it will be seen that, if the machines have strong and unyielding teeth (or powerful synchronising qualities), they will make a prodigious effort to keep in step whatever happens. This analogy affords an explanation of the difference in the way in which the synchronising current circulates between alternators of the two kinds. With spur wheels of the strong type it will be seen that any transfer of power will be immediate and prompt, the correcting impulses being transmitted with decision and sharpness, the lagging or yielding permitted being only that due to the space between the teeth. This corresponds with the short sharp impulses of synchronising current between two alternators of one type; while the slow and sluggish impulses of current between two alternators of the weak field type is understood by imagining what would happen with an attempted interchange of power between the two engines geared to a shaft by teeth of some yielding material.

A further analogy and I have done, to show those who are at all familiar with the mechanics of spur gearing how unnecessary it ought to be, so far as the machines are concerned, to reduce the number of magnetic teeth, or periods, in order to get satisfactory and smooth driving, either singly or parallel. It is only in cases where the electrical spur wheels are so designed that the teeth cannot get in, that a small number of periods can be of any service (so far as the machinery is concerned). Steady and smooth driving is rather to be sought in the other direction.

DISCUSSION.

Mr. Raworth, who opened the discussion, said that the Institution was dependent upon Mr. Mordey for experimental facts relating to the working of alternators, though many members came forward with theories. This was probably owing to his exceptional facilities at the Brush Company's works. He considered that other companies should be equally generous to their employés and afford them opportunities for bringing forward information to the Institution. Prof. Forbes had discovered a mare's nest, and Mr. Mordey had explained it away; but he had not got quite to the bottom of it. Every governor "hunted," and that would be the case until they could get rid of friction. The same results as Prof. Forbes complained of would have occurred had two continuous-current machines been employed. It was nothing in the world but common mechanical effect.

Mr. Sparkes stated that the principal difficulty was to secure suitable steam engines. Compound engines were more satisfactory than single-cylinder engines.

Mr. Kapp congratulated the author on his exceedingly happy analogies, but he had contrasted spur wheels with hard teeth and with flexible teeth to the disadvantage of the latter, and suggested that flexibility conveyed the idea of weakness. There was, however, no reason why flexible teeth should not be equally strong. The flexible teeth yielded until they attained force. Mr. Mordey had hardly done himself justice in his experiments. Had he put on a mechanical load of, say, 50 kilowatts, such as would occur in a transmission installation, the machines would have dropped out of step far sooner. If they had a long line and could not afford much copper, then it was advisable to have the motor at lower excitation than the generator, but they had it in their power to raise the voltage and have little line loss. Then this would not be the case. A margin of power was required where heavy machinery was suddenly set to work, and then the motor should be excited higher than the generator. At Bristol, where he and Mr. Preece had laid out an installation, an even torque was necessary, and engines with three cranks were found very satisfatory.

Prof. Silvanus Thompson remarked that it was desirable to have further discussion from other makers of alternators in regard to running them on a large scale, especially in the case of the transmission of power along a line. There was no doubt that a special motor would have to be designed to work at the end of the line. He thought that the author deserved thanks for the analogies referring to gearing. There were other ways of synchronising than those already mentioned. There was the acoustic synchroniser, which howled all day and gave information to the ear instead of to the eye. Had no one any experience of optical synchronising attached to the machines? At Rome the alternators were set in a line, and one could look through one machine on to another and see when the machines were synchronised by observing the rotating of the magnets of one machine across those of another. It was quite possible that some optical synchroniser might be found better than the method of using lamps or acoustic appliances. He asked whether any of them had any information on the use of a common steam supply to the engines driving the machines to be put in parallel or which were running in parallel. It was desirable that an opinion, or, rather an actual experience, should be given under different circumstances with different types of engines, types of governors, and of alternators, especially as to the conditions under which the machines were run most satisfactorily in parallel.

The President adjourned the discussion to the 29th inst.

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THE
ELECTRICAL ENGINEER.

Published every Friday.

Price Threepence; Post Free, Threepence Halfpenny.

Editorial and Publishing Offices:

139-140, SALISBURY COURT, FLEET STREET, LONDON, E.C.

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THE GUILEFUL PATENTEE.

Twelve or fourteen years ago a number of men obtained patents for which they have since obtained large sums of money, either in the lump from companies formed for the working of the patents or in the shape of royalties. These valuable patents can almost be counted upon the fingers, though the total number of patents taken out may number hundreds, perhaps thousands. As soon as a new departure is made in any direction, scores of professional inventors set themselves to work to see if they cannot possibly devise something that will enable them to get round the original patent. There is another class of men whose conduct we wish to bring into discussion—the small capitalist. Thousands of men are in great haste to get richer. Many have been long years in business, and by care, intelligence, and industry have saved a competency and retired. These men, unfortunately, seem easiest bitten with the mania for increasing their store by dabbling in patents. Periodically, some such person invites our attention and asks our advice, having financed the impecunious inventor to the extent of hundreds, sometimes thousands of pounds. There is no remedy. In no single case have we ever found the invention worth a moment's consideration, or having the commercial value of a brass farthing. Those who advanced the money are often ruined, or reduced to very straitened circumstances. Inventors, almost without exception, are favoured with the gift of the gab. Many of them believe anything they want to believe, and in flowing, flowery language tell their dupes of the immense sums to be realised and the revolution to existing industry when their invention is perfected and put upon the market. Unfortunately, perfection is like the millennium — always in the distance. Money gets tight before the invention is ripe for use. This is a state of things it is desirable should no longer continue. The glamour of the early eighties dies hard. Men are still duped. Almost every week advertisements appear in the daily papers for pecuniary assistance to exploit some electrical invention. This is when the inventor has ruined his dupes obtained privately, or when he cannot obtain such dupes. There is another class of inventor or exploiter, forming a fairly large colony in London, comprised of many nationalities—English, French, German, and American—each member of which haunts the City, calls upon every company promoter with an invention for the exploitation of which he proposes a company should be formed. Thank goodness, company-mongering has of late been somewhat dead. But if there should be a revival, we have no doubt attempts will be made to float companies to run some of these woe-begone inventions. It must be understood that a company promoter has but one object—to make money. The intrinsic value of the patent is nothing to him, provided he can get sufficient satisfactory reports—which again is purely a question of money—and make up a prospectus that shall enable him to victimise the public. After he has got his promotion money, so far as he is concerned, the deluge may come as quickly as it likes.

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In our opinion, the public, whether asked privately or publicly, should be exceedingly chary in opening its pockets for the exploitation of patents. We are perfectly certain there are firms and companies existing managed by level-headed men who have a comprehensive knowledge of what is wanted. These men are always ready and willing to examine carefully the value of any patent submitted to them. They are only too glad to obtain an improvement that gives them a practical monopoly in a particular direction, and assists them in the competition against rival firms. The public is not required to waste its money, and may take it for granted that when asked to subscribe to syndicates or companies for the purpose of purchasing patents, the patents offered are almost wholly or quite valueless. We have called attention to this subject at the present juncture because there is a kind of revival among these inventors, and men are being asked largely in private and in public to invest in patents that are of the most trumpery character. Money obtained in this way ought to land those who get the money in the criminal dock for getting money under false pretences. However, the law does not recognise this as a crime; so all that can be done is to warn capitalists against the charming of the patentee who has patents for sale.

GOODWILL AND CONVERSION.

There is, perhaps, no great advantage in the consideration by lay minds of intricate legal points, though very often questions of equity are more easily decided by the application of a little sound common sense than by a million arguments from learned counsel. When it comes to interpreting Acts of Parliament, the task is even harder, and of considerably less use, for ordinary minds are not supposed capable of suggesting facts or consequences.

It may be, therefore, complete waste of time to discuss the question of what sums ought to be paid as "the then value" to tramway companies by local authorities when the latter desire to exercise their right of purchase of lines and equipment under the Tramways Act of 1870. Yet, owing to the importance of the final decision (whenever it may be given by the House of Lords as a last court of appeal) to the electrical industry, we deem it worth while calling attention to what may be the probable consequences of construing the words of the Act in one way or the other.

If "the then value" is held finally to mean so many years' purchase of the tramway company's business—that is, must include goodwill, over and above the estimated worth of the plant and equipment—then there is little doubt but that few municipalities or local authorities will exercise their rights of purchase, and take over the lines when the opportunity occurs. At the present time there are hardly any tramway companies which possess a financial standing sufficient to enable them to convert their system of working so as to employ electricity as the motive power, and the consequence will be that electric traction must suffer a severe set back. On the other hand, if the municipal authorities are enabled to purchase the lines upon reasonable, if not highly favourable, terms, they can borrow money at such low rates as to make it quite easy to adopt electric traction by equipping the lines with overhead wires and erecting generating stations, etc., on a large scale.

We do not expect shareholders in tramway companies to undergo financial martyrdom for the sake of electric traction; but there ought to be some middle and fair way out of the difficulty. In the case of electric lighting schemes, the maximum time allowed the promoters in which to make a reasonable profit is double the limit given to the tramway companies for the same purpose, but specific mention is made by Parliament that goodwill or profits, past and future, must not in such a case be taken into account. When the consequences to electric traction may prove so serious, it is much to be regretted that the two classes of undertakings cannot be in some way put upon the same level. We hope, at any rate, to see efforts made in this direction.

The question of municipalities *working* the tramway lines does not, of course, enter into the dispute. Most people seem agreed upon the advisability of local authorities *owning*, and therefore being allowed to purchase, undertakings of a public nature such as gas and water supply, electric lighting, and tramways, etc. The point seems to turn upon what shall be the price which local authorities ought to pay for undertakings already established (whether they intend to work or to sub-let them), and we think the decision of this question will have a very important bearing upon the development of electric traction.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

RUNNING ALTERNATORS IN PARALLEL.

SIR,—Mr. Proctor's letter, as most of the information given on the above subject, deals only with the *possibility* of running alternators in parallel, but not with what affects central-station engineers most—viz., *practicability*. We all know that alternators *can* be run in parallel—but what is gained by doing so? It is an acknowledged fact that it takes some time (and this time is most uncertain, varying from half-a-minute to four minutes or more) to get the machines properly synchronised before they can be switched on to the mains. In the case of a breakdown, in which, say, one machine is incapacitated and has to be switched out, this time is most valuable, as all the while the other machines are overloaded, or should be if parallel running is used economically and not with a big margin of safety. Again, supposing a good number of alternators are running in parallel on one pair of mains, we get a repetition of the recent Bankside breakdown.

We can run our machines in parallel in Bath, but find the system of having many circuits, any of which can be switched separately on to any machine, much more reliable. We can thus load up our machines to their full capacity, and in case of a breakdown another machine is run up to speed far more quickly than it takes to synchronise.

Some of the new stations are so designed that parallel running is forced upon the engineers, others are arranged to run either in parallel or separate circuits on separate machines (like the Bath station), and others only on the separate circuit system. I have noticed that when the engineer has the option of using either system, he almost invariably uses the separate circuit system; and when he only has the latter system, he is in no hurry to adopt parallel

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running. And I firmly believe that the engineers in charge of stations in which their alternators can *only* be run in parallel would prefer, if they had to choose, either of the other systems rather than be bound to the one. But engineers in charge do not, as a rule, design their own stations, and central-station designers do not have the responsibility of a heavy winter's run.

Until some reliable means of automatically cutting out machines in cases of breakdowns, as used with continuous current, and a more rapid and satisfactory system of synchronising is discovered, I cannot see that parallel running for alternators will ever be a thorough success.—

Yours, etc., G. F. METZGER,
Chief Engineer, Bath Electric Light Company.
March 7, 1894.

REVIEWS.

Electricity in the Service of Man. G. R. WORMALL, D.Sc., M.A. From the German of Dr. A. R. von Urbanitzky. Revised and enlarged by Prof. R. M. Walmsley, D.Sc., F.R.S.E. With more than 950 illustrations. Cassell and Co.

The new edition of this book differs considerably from the old. Much irrelevant matter has been displaced, and large additions have been made. We do not agree with many of the scientific explanations given. They are wrong; but, as a matter of fact, in this book science may be ignored, and the notice of it restricted to descriptive matter only. If we were asked to define the aim of the book we should say it was intended to be a descriptive encyclopædia of applied electricity. The author and editor seem to have desired to bring within the covers of one book a correct, graphic, if not lengthy, description of every piece of modern electrical apparatus that has been devised and come into use, whether such use is restricted or almost universal. Further, description is given of much of the apparatus now becoming historical, when that apparatus has formed a step in the advance from the earliest attempts to that at present in use. Indeed, in some cases so anxious has been the editor to miss nothing that he has described in his text apparatus that has no more to do with electricity than it has with the manufacture of sugar. The editor knows this, and why, thus knowing, he includes the phonograph in an electrical treatise is beyond comprehension. With the exception of these minor blemishes, the present editor has produced a book which is by far the best of its kind. The information he has collected and given is immense. The descriptions are clear and accurate, the illustrations good and ample, and altogether the book is one that should be exceedingly valuable to all who wish to obtain a good general idea of the various applications of electricity. It is intended to be a popular book, and it admirably fulfils that intent.

The Inventions, Researches, and Writings of Nikola Tesla, with Special Reference to his Work in Polyphase Currents and High-Potential Lighting. By THOMAS COMMERFORD MARTIN. *The Electrical Engineer*, New York.

Whatever we may think of the heroic action of the soldier who gains the Victoria Cross, there is little doubt but that all scientific electricians will place the heroism of Nikola Tesla upon a higher pedestal. The man—no matter the reasoning which led him to it—who first hazarded the action of enormously high-potential currents could not help being heroic. Scientific heroism which leads doctor or physicist to test in his own person the value of a theory is to our mind a higher form of heroism than mere physical bravery. And Nikola Tesla stands pre-eminent in the electrical world as having himself tested his theories. Mr. Martin has been very active in collecting all the information that has appeared about Tesla's work. Our readers are not unfamiliar with much that he has done, but they will find it more completely set forth in the pages of this volume. The editor acknowledges that a large amount of the practical work carried out by Mr. Tesla is as yet unpublished. This of course is only what we should expect. Mr. Tesla wants to apply his theories, and is experimenting for that purpose. These experiments are not for the world till the author's chosen time. We are all waiting for future revelations, and we can only say that Mr. Tesla's published results have already placed him high among both theorists and practical men, and that Mr. Martin has produced a volume so far exhaustive, worthy of the theme he discusses.

THE PATIN AND LEVAVASSEUR MACHINE.*

The machine we are about to describe is composed mainly of the following parts: (1) an inductive system composed of an iron ring with eight poles alternately positive and negative, projecting inwardly, and a star-shaped interior core, upon the radial segments of which are mounted the exciting coils so as to present poles of opposite sign to those on the ring; (2) an armature composed of 10 flat coils, or two more coils than there are poles; and (3) a 40-bar commutator, to which the armature coils are connected. Fig. 1 shows the connections between the armature coils (which rotate, as shown, between the inner and outer rings of poles) and the commutator.

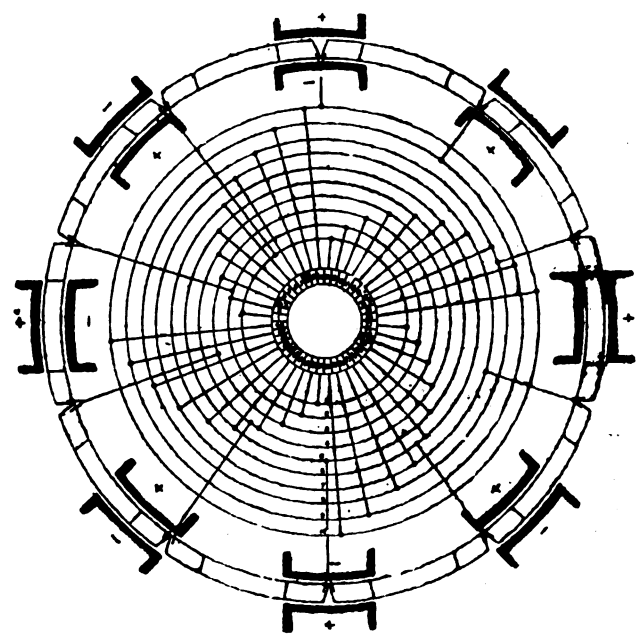

FIG. 1.

The core and poles of the field magnets are built up of iron plates. The armature is made up of 10 coils, each in shape of a flat elongated oval, and are composed of copper ribbon insulated with fibre; after being coated with shellac they are bent, so as to lie flat upon the circumference of an insulated metal drum parallel with the dynamo axle, to which the drum is keyed by means of a spider. They are bolted upon the drum at one end only. The other ends of the coils project from the drum parallel with its axle, the overhang being enough to allow the coils to be rotated in the narrow annular space between the inner and outer poles. They form a closed continuous circuit, so that if the circuit is interrupted at any point while the machine is running the coils become solenoids, presenting alternate positive and negative poles. From ten points of junction the coils are connected by the same number of wires with ten different insulated rings. The bars 1, 11, 21, 31 are connected with ring 1; bars 2, 12, 22, 32 are connected with ring 2, and so on, up to bars 10, 20, 30, and 40, which latter is joined to ring 10. The machine chosen for illustration is an eight-pole and ten-coil machine, but so long as the same principle is preserved these numbers may be increased.

When the dynamo is running as a constant-current generating machine, eight brushes may be arranged round the commutator at a distance of five bars from each other, and connected in parallel in pairs. Many other combinations may be made with two or more brushes. Ordinarily, the machine has only two brushes disposed on the commutator—5, 15, 25, or even 35 bars apart. Suppose, for instance, they were 15 bars apart. If the machine is generating current, the brushes should be in contact with

* Abstracted from *L'Electricien*.

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the bars X and Y (shown in Fig. 1 at segments 3 and 18); if it is running as a continuous or alternate-current motor, the brushes should be in contact with bars Z and U, or segments 8 and 23.

Let us now consider a machine (Fig. 2) with four pole-pieces and six armature coils. Careful attention should be paid to the four poles, the six coils, and the twelve bars of the commutator. In the position shown in the figure, coil 1 is in front of pole 1 and coil 4 in front of pole 3. One rotation—clockwise — equal to $\frac{2\pi}{12}$, corresponding to the angular opening of a segment of the commutator, will bring coil 2 in front of pole 2, and coil 5 in front of pole 4. A second rotation of $\frac{2\pi}{12}$ brings coil 3 in front of pole 3, and coil 6 in front of pole 1. It will also be seen that for the coincidence of a pole with a coil a rotation is required of $4 \times \frac{2\pi}{12}$ or $\frac{2\pi}{3}$, and that for each complete revolution of the machine this coincidence must occur three times.

What, it may be asked, are the relations between the movement of this coincidence and the number of poles and coils?

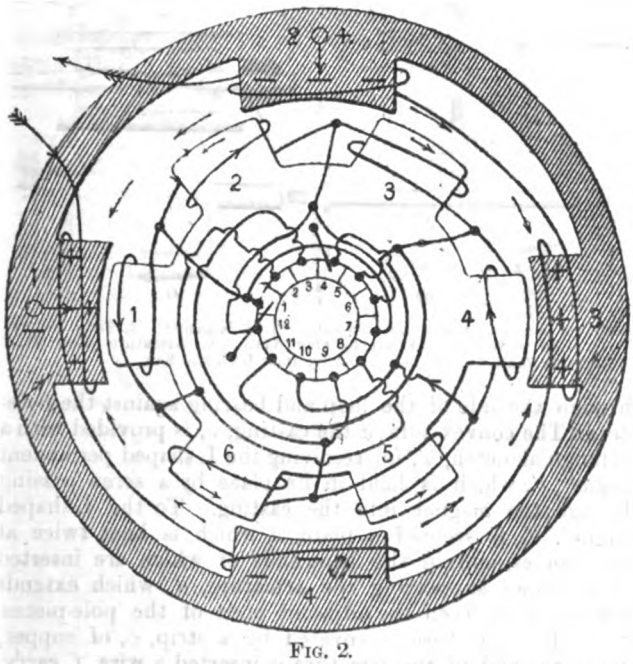

FIG. 2.

Let p be the number of field coils or poles, and $p+2$ the number of armature coils. We know that for an angle equal to $\frac{2\pi}{\frac{p(p+2)}{2}}$ the coincidence of coil and pole will advance one pole. Consequently, it will move once round for a rotation of $p \frac{2\pi}{\frac{p(p+2)}{2}} = \frac{2\pi}{\frac{p+2}{2}}$. That is to say, the coincidence travels once round for an angle of advance of $\frac{2\pi}{12}$ if there are 24 coils and 22 poles.

Having so far explained the importance of this coinciding of coil with pole, its rotary movement and relation to the number of coils and poles, it may be added that at each instant all the coils to the right and within the limits of a semicircle—moving in the same way as the hands of a watch—furnish currents of the same sign, whose E.M.F.'s are superadded to one another. The same may, of course, be said of the coils moving in the semicircle to the left. If two collectors are mounted so as to coincide in position with what we have called the "coincidence" itself—*i.e.*, coil and pole coming opposite one another—and follow the same course, moving with the same speed, a direct current may be collected from them. The coils to the right and left of such "coincidence" are practically connected in two parallels, and may be compared with the two halves of the armature of a continuous-current dynamo.

In the four-pole and six-coil machine we have seen that the angle of rotation which advanced the coincidence of one pole was $\frac{2\pi}{12}$, and that, generally speaking, p being the number of poles, and $p+2$ the number of coils, that angle is equal to $\frac{2\pi}{\frac{p(p+2)}{2}}$. It is easily understood that if the segments of the commutator preserve a relative angle, the brushes will always follow the course of the coincidence. The number of segments is given then by the expression $\frac{p(p+2)}{2}$. When the coincidence makes one turn, the brush passes p segments, and the coincidence makes one turn for an angular displacement of $\frac{2\pi}{\frac{p+2}{2}}$, and p turns for a complete revolution of the machine.

The coils furnishing positive current are $\frac{p+2}{2}$ in number, and an equal number of coils supply negative current. The segments are numbered from left to right. They are connected to the armature coils from right to left, and in this way $p+2$ coils are joined to $p+2$ bars of the commutator. The $(p+3)$rd bar is joined to the first, and so on; therefore $\frac{p}{2}$ bars are in connection with each coil.

The brushes are adjusted in such manner that they collect from the coils in coincidence. As the machine rotates, it will be seen that, in spite of the coincidence movement, the brushes always remain in a relatively constant position with the coinciding coils. In effect, the angle of rotation representing one turn of the coincidence includes p segments.

HOW TO MAKE A TELEPHONE CALL.

No telephone line is complete without a signal of some kind which will serve to attract the attention of a person in the vicinity of the instrument. A battery call answers very well for short distances, but for a distance of from one to twelve miles or more the battery has been found impracticable, and the magneto call is generally employed. This instrument, not only serves a good purpose in connection with the telephone, but it answers very well indeed for general signalling purposes. It is always ready for action, and does not involve the care of a battery.

The pole-pieces, A A′, between which the armature, B, revolves, are formed of soft grey cast iron, with ears, *a a*, at the top and the ears, *b*, at the bottom, separated by bars, C C′, of non-magnetic material, such as vulcanised fibre, hard rubber, or they may be made from hard wood, well varnished or saturated with paraffin to prevent them from shrinking or swelling. The pole-pieces, A′ A′, are clamped to the bars, C C′, before they are bored out. They are bored out to loosely fit the armature, B. The pole-pieces are provided with flanges, *c*, which rest upon the bottom of the casing, and are drilled to receive screws, *d*, by means of which the magnet is secured in place in the casing. In the pole-pieces, A A′, above the ears *b* are drilled and tapped holes, *e*, for receiviag the studs, *f*, by which the horseshoe magnets are secured to the pole-pieces. The studs, *f*, are drilled for receiving keys, *g*, by which the magnets are clamped in place.

The compound magnet, D, is composed of three flat steel bars, forming U-shaped magnets, *h*, *h′*, h^2, with the space between the poles adapted to receive the pole-pieces, A A′. The magnet h^2 fits over the adjoining edges of the magnets *h h′*, and the three magnets are drilled to receive the studs, *f*, which extend through the magnets and into the pole-pieces, the parts being clamped together by keys driven through the holes in the studs, as shown in the perspective view.

The armature, B, is the well-known H-type of Siemens, made of soft grey cast iron, the shaft, *i*, being cast integrally with the body of the armature. The part, *j*, which receives the wire is narrower and shorter than the polar extremities of the armature. The armature is turned

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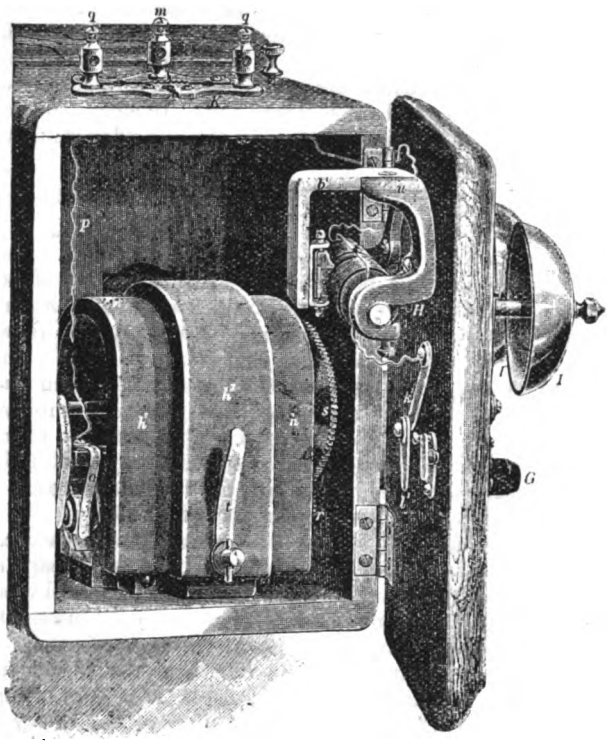
so that its convex sides will revolve very near but not in contact with the pole-pieces. The shaft at the ends of the armature is turned, and to one end is fitted a sleeve, *k*, of insulating material (vulcanised fibre or hard rubber), on which is placed a brass ring, *l*. In the inner side of the metallic ring, *l*, is inserted a stud, *n*, to which is soldered one terminal of the armature coil, the other terminal of which is soldered to a screw, *n*, inserted in the shaft, *i*. The armature is wound in the same manner as an electro-magnet, the wire being carried around one arm of the armature until one-half of the wire is in place. It is then carried across the central portion of the armature and wound upon the other arm of the armature. The wire used is No. 34 silk-covered wire, there being about 1½oz. of wire upon the armature, or enough to give it a resistance of 200 ohms.

To the bar C is secured a brass plate, E, by means of screws which pass through the plate and into the bar. In the plate, E, opposite the centre of the bore of the pole-pieces, there is a bearing for one end of the shaft of the armature, and in the opposite or upper end of the brass plate, E, there is a bearing for the driving shaft, F. To the opposite end of the bar C and to the bar C′ is secured a plate, E′, which is also provided with bearings for the armature shaft and for the driving shaft. To the bar C is secured a curved spring, *o*, which bears upon the insulated ring, *l*, and this spring is connected by a wire, *p*, with a binding post, *q*, at the top of the casing.

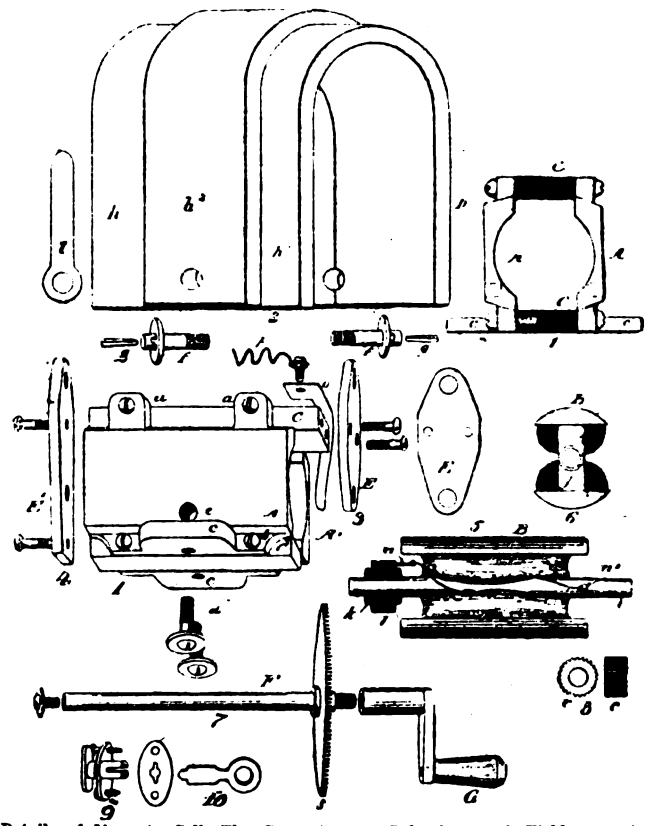


Magneto Telephone Call.

Upon the end of the armature shaft, *i*, outside the plate E′ is placed a pinnion, *r*, and upon the shaft, F, is placed a spur wheel, *s*, which engages the pinion, *r*. The shaft, F, is held in place in the machine by a screw inserted in the end of the shaft, and a washer held by the screw against the end of the shaft and bearing against the plate E. The crank, C, by which the shaft, F, is turned, is screwed on to the end of the shaft through an aperture in the side of the casing. On the stud, *f*, projecting through the front of the magnet is placed a contact spring, *t*, which is clamped by the key which holds the magnet in place.

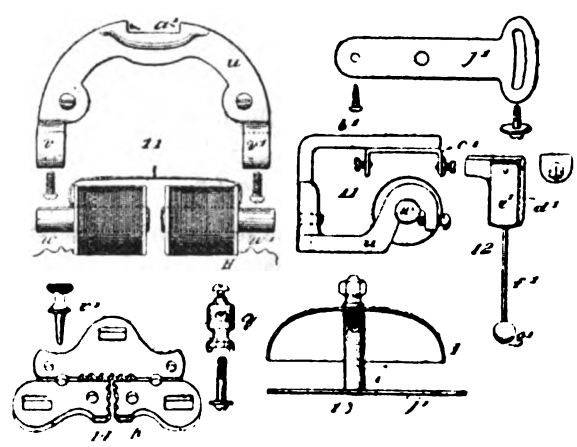
The mechanism thus described comprises the magneto generator which generates the alternating current required for operating the magneto bell. The machine is held in place in the casing by the screws, *d*, as already described, and the back of the casing is cut away to let the magnet h^2 into the back, thus economising room. To the cover of the casing is attached the magneto bell, H, the magnet and armature of which are placed within the door, while the bells are placed on the outside of the door, the hammer extending through the door and between the bells.

The body of the magneto call consists of a curved casting, *u*, which is secured to the inner face of the door and provided with loops, *v v′*, for receiving the soft iron pole pieces, *w w′*, of the bell magnet. These pole-pieces are held in place in the loops, *v v′*, by screws passing



Details of Magneto Call—The Generator.—1. Pole-pieces. 2. Field magnet. 3, 4. End plates. 5. Armature, Side View. 6. Armature, End View. 7. Driving Shaft. 8. Pinion. 9 and 10. Door Lock and Key.

through the side of the loop and bearing against the pole-piece. The convex side of the casting, *u*, is provided with a rectangular notch, *a′*, for receiving the L-shaped permanent magnet, *b′*, which is held in its place by a screw passing through the magnet into the casting. To the L-shaped magnet, *b′*, is secured a plate, *c*, which is bent twice at right angles, and in the bent ends of which are inserted pivot screws supporting the armature, *d*, which extends downward between the adjacent ends of the pole-pieces, *w w′*. The armature is covered by a strip, *e′*, of copper, and in the end of the armature is inserted a wire, *f*, carrying at its extremity a bell hammer, *g′*. To the outer surface



Details of Magneto Call—The Bell.—11. Call Magnet. 12. Armature. 13. Bell. 14. Lightning Arrester and Cut-out.

of the door, and on opposite sides of the bell hammer, are supported two bells, I, by studs, *i′*, projecting from adjustable plates, *j′*, pivoted to the door at one end and provided with a curved slot at the opposite end for receiving a clamping screw, which passes through the slot and into the door. By means of this device the bells may be adjusted so that each will receive a stroke of the same power from the bell hammer, *g′*.

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The spools on the pole-pieces, *w w'*, contain about 1½oz. of No. 34 silk-covered copper wire. They are wound in the same direction, and the inside ends are connected together. The outer end of one spool is connected with the upper hinge of the casing, which, in turn, is connected with the binding post, *q'*; the outer end of the remaining spool is connected with a strip, *k'*, of copper attached to the door and connected with a plate, *l'*, which comes into contact with the spring, *t*, when the door of the casing is closed.

On the top of the casing there is a plug switch, which also answers as a lightning arrester. The rear plate of the switch is provided with the binding post, *m*, which is connected with the ground. The binding posts, *q q'*, receive the ends of the line wire, the connections being made as shown in the article on the telephone in *Scientific American*, February 3.

When the call is placed at the end of the line, the call-box is grounded by inserting the plug, *r*, between the rear or ground plate and the front plate that is not connected with a line wire. When it is desired to cut the call-box out of the line, the plug is inserted in the circular space between the two front plates, the current passing from one end of the line through one of the binding posts and plate to the plug, the other plate and binding post to the other portion of the line. When the armature, B, is turned by revolving the crank, G, opposite ends are alternately presented to opposite poles, the consequence being that the rapid changes of magnetism in the armature induce alternate pulsations in the winding of the armature which operate the polarised bell of the instrument, also the polarised bell of the distant instrument, both being normally in the circuit.

While talking over the line, it is important to cut out the magnet on account of its resistance, and while signalling over long distances the signals are more effective if the telephones are cut out of the line.—*Scientific American.*

HOW TO MAKE A TELEPHONE.

The following description and cuts of a telephone very simple to make we borrow from the *Electrical World*, which states that it will give excellent results on lines up to five or ten miles in length, when used both as a receiver and transmitter. If used in connection with a transmitter, it will answer for any length of line. If the line is to be constructed in close proximity to electric railway or light wires, it should be made a metallic circuit, but elsewhere a grounded circuit will answer just as well.

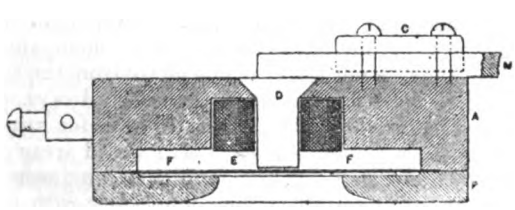

FIG. 1.

The material required for a set consisting of two telephones, one for each end of the line, is as follows: 1oz. No. 36 silk-covered magnet wire; two horseshoe magnets, 4in.; two flat-head stove bolts, ¼in. diameter and 1½in. to 2in. long; a piece of photographer's tintype large enough to cut from it two round diaphragms 2½in. in diameter; four small wood screw binding posts; 12 flat-head brass screws ¾in. long. Use well-seasoned mahogany, or any hard wood, about ⅞in. to 1in. thick for the main case, and for the cover that ¼in. or ⅜in. in thickness is best. The pieces of wood should be larger than the dimensions given, and if marked and bored before sawing to the size desired, there will be less likelihood of splitting.

From Fig. 1 the dimensions for the holes in the wood can be obtained. The 2½in. space under the diaphragm, F, can be bored with an extension bit or marked out with a compass and cut out with a chisel. The 1in. hole should be bored with a bit which has no lip, in order to leave strength sufficient for counter-sinking the head of the stove bolts. The depression in the lid need not be as deep as shown, but merely enough to clear the diaphragm. The stove bolt should be cut to a length a little longer than necessary and then carefully filed and fitted by trial, so that when in place it will just clear the diaphragm.

For the wire a spool should be made of cardboard to fit the bolt and central hole neatly; the spool with wire, E, is wrongly shaded in the cut.

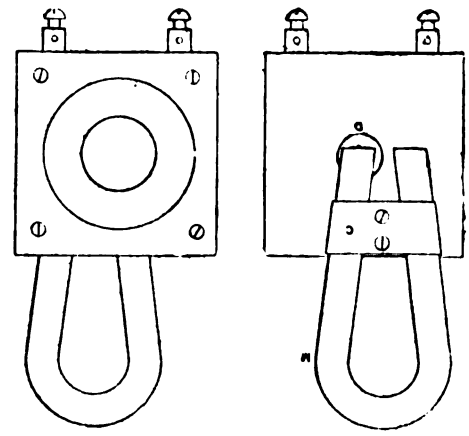

FIG. 2.

The magnet is held in place, with one pole over the bolt head, by a piece of wood, as shown in Fig. 2, the part between the legs of the magnet just clearing the bottom when the screws are home. The ends of the wire are brought to the binding posts through two small holes bored in the wood. Magneto bells are the best, and, in the end, the cheapest for use as call bells in connection with the telephone.

THE ELECTRIC LIGHTING OF SORTING-TENDERS.

A paper was recently read before the Electrotechnical Society of Berlin by Herr C. Grawinkel, one of the German Post Office officials, on the electric lighting of postal sorting tenders on railways in Germany, a subject to which we have previously briefly referred.

The author first gave statistics showing the immense amount of work done in such tenders. An important point in connection with the tenders was the lighting arrangements, which should cause as little increase of the temperature as possible, should not make the air foul, and should not be liable to cause risk of fire. Since 1875 gas lighting had taken the place of oil, and was better, but it caused heat, and the air was affected by the products of combustion; the light was not steady, and though danger of fire was not much to be feared, it was nevertheless possible. The attention of the authorities was consequently given some time ago to the question of lighting the tenders electrically. The lighting of a single wagon in a train did not offer the same difficulties as lighting a whole train, and the improvements in accumulators within recent years induced the Post Office to make a trial. Favourable results were obtained in tests made with accumulators furnished by Herr Böse, of Berlin, and in the middle of May last an experiment was made with them between Berlin and Frankfort-on-the-Maine. A battery of 16 cells was employed, supplying current to eight 12-c.p. incandescent lamps. The result was successful, and it was determined to carry out further experiments on other tenders. These are run on the night expresses between Berlin and Frankfort, Berlin and Eydtkuhnen, Berlin and Leipzig, Berlin and Dresden, Berlin and Alexandrowo, Berlin and Cologne, and Berlin and Breslau.

Batteries.—The batteries for long journeys consist of two sets each of 16 cells. Each cell contains five positive and six negative plates. Each set of four cells is placed in a wooden box, protection of the glass cell against jolting being obtained by coverings of "colophonium." Even if the glass cracks the fluid does not escape through the surrounding material. The capacity of a 16-cell battery is 115 ampere-hours, making for the two a total of 230 ampere-hours, and at an average pressure of 1·9 volts for the cells, 6,992 watt-hours are obtained.

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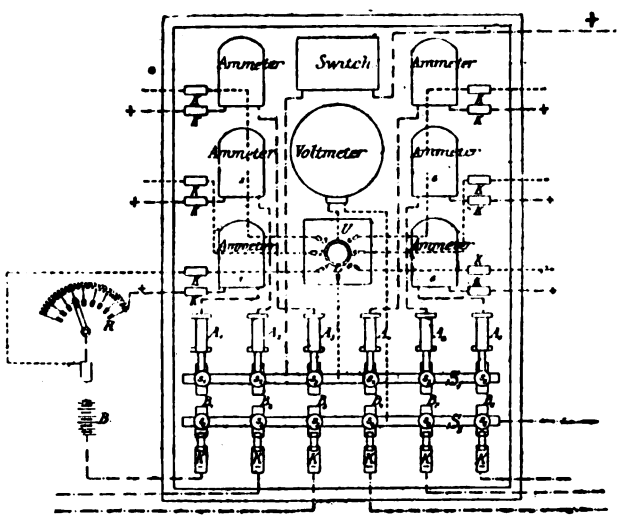
Lamps.—Two sorts of lamps have been employed—namely, 12-c.p. Khotinsky lamps for 30 volts and 0·8 ampere, and 10-c.p. lamps of the type made by the Allgemeine Elektricitäts Gesellschaft, for 30 volts and 0·75 ampere. The Post Office has not yet decided which of the two is the better. The jolting of the wagons has a marked effect by causing rupture of the filaments. So far it has been found that after 10 lamps have been in use a total of 250 hours, one is found faulty. Nine incandescent lamps have taken the place of nine gas lamps in a 40ft. tender. There is much increased convenience, as the lamps can be placed in better position for the sorters. Each lamp can be switched on and off independently, and there is a switch to control the nine simultaneously.

Conductors and Safety Appliances.—The leads offer no difficulties. Wire, with good insulating material, is employed. The wire is carried free in such parts where it will not be injured, and elsewhere is covered with wood. The safety appliances consist of a lead safety fuse for each lamp, which cuts it out as soon as the current reaches four amperes, and a double-pole lead safety fuse for 15 amperes for a whole installation.

Consumption of Energy.—The duration of the lighting depends upon the length of the journey. For instance, between Berlin and Frankfort and Berlin and Eydtkuhnen the return trip takes from 24 to 27 hours. According to the length of the journey, two batteries connected together are employed, or one battery with reserve batteries which are switched on during the return journey, or only one battery. The figures given as to the capacity of the accumulators and the consumption of energy of the lamps show that the batteries will suffice for the longest journeys.

Charging.—At first the accumulators were charged at the head telegraph office in Berlin, but a special charging station has now been established at the Anhalt railway station. Current is taken from the mains. At present two charging circuits are in use. In each circuit two batteries, each of 16 cells and connected in series, can be charged, so that about 85 volts are required as the necessary charging pressure. The strength of the charging current is five amperes, and the charging of two batteries will accordingly take place within 24 hours. The



annexed illustration shows a larger installation with six charging circuits. The positive charging conductor is connected to a switch, while the negative lead is connected with the cross-rail, S_2. Attachments from this cross-bar are connected with the negative poles of the 32 cells. In the diagram the connection for a single battery is shown. From the switch the positive conductor of the charging circuit leads to the cross-bar, S_1, through an ampere-meter, and from there to a rheostat, R. Each circuit thus has its own ammeter and rheostat, R. From the second terminal or rheostat, a conductor leads to the positive pole of the battery to be charged. For the whole charging circuits there is provided a common voltmeter, besides a multiple switch, U, so that, as shown in the diagram, each battery is connected in the simplest manner with an ammeter. The batteries (which consists of eight boxes, each of four cells) to be switched in on each charging circuit are pushed in suitable stands, and connected with the charging bars. This method offers few difficulties, and can be quickly learned by an under official.

The object of the experiments has been attained by the provision of a steady, healthier, and more convenient illuminant for the sorters on the tenders, which will lighten their labours and improve the service. Cheapness was not an object of the authorities, but the experiments have already shown that under favourable circumstances electric lighting may prove cheaper than the gas-lighting.

REGULATIONS FOR ELECTRIC SUPPLY—ROUEN MUNICIPAL COUNCIL.

A schedule of conditions and rules for the installation of public electric supply systems has just been issued by the Municipal Council of Rouen, and we abstract from *L'Electricien* some of the principal regulations under which "undertakers"—to use a well known expression—may be able to supply current from central stations for any and every possible purpose in that town.

No authority or concession will be granted except to French subjects or to French companies with a registered office in the town; the Compagnie Europeenne du Gaz is, however, specially mentioned as exempt from this condition.

Any person or company obtaining a concession must be represented in the town by French subjects having full powers to deal with any question involved, and must undertake, on equal conditions, to give the preference to local manufacturers for all requirements necessary when carrying out and operating any concession.

For overhead wires the concessionary must obtain all needful authority from the Imperial Government, and carry into effect any conditions laid down by the telegraph service. He must also obtain all wayleaves, and cannot use any public building as a support for aerial cables without special written authority from the municipal government. Moreover, he must indemnify the latter from any claims which might be brought against him in consequence of this concession. Branch mains in each case are to be provided, erected—as far as the electricity meter—and maintained by the undertaker at the consumer's expense. The former alone will keep a key to the switches provided by him on the branches to consumer's premises.

Underground mains will not be permitted in subways or sewers. They are, as far as possible, to be placed under the footpaths, in earthenware, masonry, or metal conduits. Their position, depth, and outside diameter will be decided by the Council's engineers in each case. Mains can only be taken under the roadways in order to cross them, and their depth must then be not less than one metre from the surface. Branch mains must not be taken across roadways. Manholes are to be provided at suitable distances for inspecting and testing the network. Their position and arrangement must also be decided by the municipal engineers. All covers are to be provided on their inner face with a layer of suitable insulating material. The cost of moving or displacing any gas or water pipes, etc., must be borne by the undertaker.

Mains are not to be laid at a less distance than one metre from the front of buildings, and the Council must be satisfied that the position adopted will ensure perfect safety to passers-by, as well as freedom of operation to the various public services making use of the streets. This minimum distance may, however, be reduced in the case of streets where the width of footpaths is confessedly insufficient to maintain its being always kept. Branch cables which enter any building must be carried over the intervening space in conduits joined to those containing the street mains.

Transformers, where used, must have cut-outs or fuses on both circuits; and only those which supply an entire street or area with current may be placed under the street-level in masonry vaults having proper manholes and facilities for inspection, and being thoroughly insulated.

Before commencing operations, the concessionary is to provide a plan of the whole network proposed, showing the

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routes followed and the diameters of all cables and wires to be employed; and this plan is to be revised every three months, corrections and additions being duly made. Other plans—as, *e.g.*, of the branch mains, the provisions made for avoiding sewers, gas and water pipes, etc.—must also be provided. Three days' notice prior to commencing work on any part of the network must be given to the highway engineer, as also when (after completion) any work of maintenance or repair becomes necessary; but in case of breakdown, notice need only be given on the same day that excavations are made.

The undertaker is required, after carrying out the work of installation, repairs, etc., to make good, both temporarily and permanently, the surfaces both of roadways and footpaths; otherwise, after due notice, it will be done by the municipal staff and charged to the undertaker. Concessions are to be granted for terms of 20 or 30 years from the date of notifying acceptance, but carrying with them no monopoly or privilege whatever. The Council reserves to itself the absolute right to grant other concessions of the same kind, even within areas affected by networks already authorised. Moreover, it reserves the power to remove, or cause to be removed, any part of established networks whenever the public service may demand it.

Absolute freedom is given to the undertaker so far as tariffs are concerned, excepting only that electric currents are to be supplied by meter, at a maximum of nine centimes per hectowatt—*i.e.*, roughly speaking, 9d. per Board of Trade unit. A supply is, if required, to be furnished for use in the municipal buildings, etc., at not more than half the above maximum rate, and in quantities up to one-tenth of the total output. Similar provisions as regards price of current are enforced with respect to the public street lighting, all material and repairs for which are to be furnished by the undertaker.

In view of possible great improvements upon the present systems of electric lighting, provision is made for holding every five years a conference of four persons—two appointed by the Council and two by the undertaker—for the purpose of examining into the conditions of supply and investigate proposed amendments. A fifth member is to be appointed by the president of the civil tribunal in case of disagreement. Such a commission is to be empowered to make any experiments or trials which may seem necessary. Its expenses are to be borne half by the town and half by the undertaker. It is to hand in a report to the Council within four months after assembling, and consequent upon such report the undertaker may be ordered to carry out the recommended alterations or amendments within a stated time. It is not, however, intended that the expenditure upon these alterations shall be so great as to reduce the net profits below 6 per cent. If the undertaker should refuse to carry them out the Council will take such steps as may seem desirable, to the length of cancelling the concession, but, of course, allowing the undertaker to appeal to the law courts.

Supply of current must, after the concession is granted, be at once afforded within the first zone or area comprised in a circle of one kilometre radius from the central station. Within a year supply must be available throughout the second zone, within a radius of 1½ kilometres; and two years are allowed for supplying the rest of the town, except in the more scattered districts.

The municipal administration is to be allowed full freedom for making the necessary tests at any time, as with the supply of gas. The meters employed are also to be sanctioned and approved by the administration, after careful tests.

The undertaker is to pay to the town as wayleave rental one-fifth of the amount of his gross receipts based on the maximum tariff herein scheduled: having already deposited as caution-money the sum of 10,000f. The concession is liable to forfeiture on the occurrence of any out of the following conditons: transferring powers to a third party; delay in supplying current over the areas conceded; suspension—part or whole—of supply without authority from the Council; non-compliance with the regulations herein laid down, etc.

The Council reserves the right of taking over the entire system at any time after the expiration of 10 years from the date of concession, upon the following terms: an annual sum, based upon the profits of the preceding three years, will be paid to the undertaker for the remainder of the term of concession unexpired, and such payment may at any time be compounded at 20 years' purchase; all plant and machinery—fixed or loose—buildings, etc., will be taken over at a valuation price fixed by experts.

At the expiry of the concession—if the undertaking has not previously been taken over by the municipality, and if an extension of the grant is not sought—the entire system shall become the absolute property of the town without any payments being made. If the concession is not extended, and the municipal administration refuses to accept the undertaking, the concessionary is to take up the network of mains, etc., and restore things generally to their former condition at his own expense.

All responsibility of damage is to be assumed by the undertaker, but injury to the network, accidentally done by contractors employed on work for the municipality, will be made good by the latter. Neglect to carry out these clauses in all their particulars will entail a fine of 20f. in each case per day until remedied. Specific fines are the following: 1f. per street lamp per 15 minutes of extinction during the hours of lighting; 1f. per day for each defect in maintenance or repair; and 10f. per day for each defective appliance not replaced within a stated time. These fines are deducted from the caution-money, which must be made up again within a week. If this is not done, the administration has the right to seize the plant and materials of the undertaker pending satisfaction.

Foreign workmen or assistants are not allowed to be employed in excess of one-tenth of the total staff, and lists of the latter must be submitted to the administration for approval.

SOME NOTES ON THE ELECTRIC LIGHTING OF THE CITY OF LONDON.*

BY MAJOR-GENERAL WEBBER, R.E., C.B.

(Concluded from page 269.)

PUBLIC LIGHTING—LAMPS.

The lamp-posts and lanterns first erected in 1891 by the contractors, to the number of 72, in some of the main thoroughfares, under the pioneer contracts, did not meet with the approval of the Commissioners, and had all in time to be replaced. The only portion which was allowed to remain was the lantern which had been designed by the Brush Company, and which I have illustrated, and called the "Raworth" lantern. My own views had advocated a different shape, having a wide pagoda roof, and sides

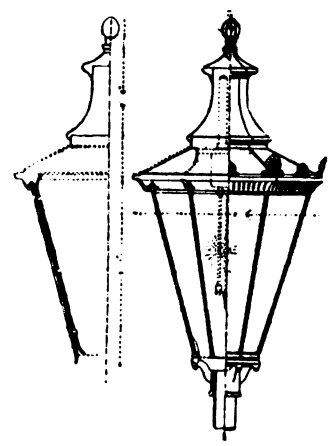

FIG. 22.—Street Lantern.

at smaller angle to the horizontal. In the case of the Raworth lantern, which is in use throughout the City, the dimensions were found to accommodate the Thomson-Houston arc lamp, as well as that of the Brush; the interior is easily accessible, and the lamp, instead of being suspended, stands on a porcelain insulator. The other details are shown on the drawing, and a sample is exhibited. As regards glass, Colonel Haywood was very particular in selecting one that was least absorbent of light, while being sufficiently diffusive of the arc. The first sample, put in by the Brush Company, which gave the effect of there being four small blurs of light inside, was rejected as being too absorbing, and perhaps requiring too much labour in cleaning. Three samples of glass were submitted to the engineer (see those in the lantern exhibited), and

* Paper read before the Institution of Electrical Engineers.

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tested by him in three street lanterns in use. They were respectively :

	Thickness. Inch.	Per cent. loss by absorption.
Ground glass	0·058	46·24
Opal	0·072	25·18
Rippled	0·145	21·73*

* These tests were, I understand, made by Mr. Preece.

The last was approved, and is now in use, and is the cheapest.

The lamp-posts, as finally designed and approved by Colonel Haywood, are in two pieces, the base having two forms; the smaller base, which is round, is fixed in the narrower footways. As regards the shaft, one matter which required careful consideration was the means of assisting the lamp-trimmer to ascend and descend. In any case, fixed projections below the lantern upon which the man can stand at his work are necessary. These are the arms shown in the elevation. Fixed projections, or means of attaching them, were not admissible on the ornamental base, but something had to be done to assist the man to mount the shaft, so as to save the carrying and use of a long ladder in the streets. The permanent attachment of steps, for obvious reasons, the Commissioners would not allow.

Three methods were proposed—namely : (1) By the Brush Company, in which short pieces of rod iron, with a round head at each end, were passed into holes in the hollow shaft at intervals on alternate sides. These rods lay concealed all except the heads when not wanted ; when in use, they were pulled out as far as the

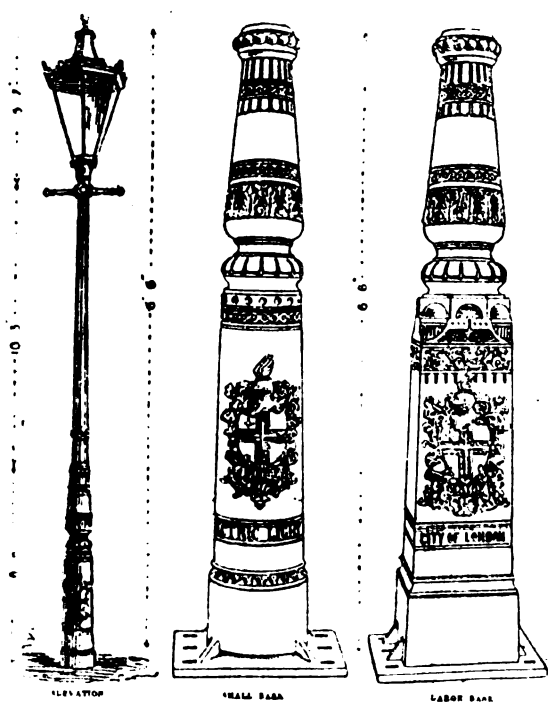

FIG. 23.—Lamp-posts.

head on the rod within the shaft would allow. (2) By Colonel Haywood, which consisted in a structure like a parallel ruler, concealed in and bedded in each side of the shaft. When shut up, no evidence of its existence could be seen ; when opened, the whole has the appearance of a ladder with a centre stave, and, but for extreme complication and costliness, it might have been a very excellent design. (3) The plan which suggested itself to me was very simple, and has been adopted. It consists in using alternate side holes in the shaft, which are not conspicuous, and in having six or eight portable steps of light steel, which can be securely hooked into the holes as he ascends, and taken out by the trimmer as he comes down the post.

Where the footways are very narrow, and posts are inadmissible, it became necessary to use wall brackets. Of one of these, illustrations in two aspects are given. The suspended lantern is the same in design as that on the posts, with some small differences in detail. It took a considerable time for the Commissioners to obtain the way-leaves for such heavy attachments to private buildings. The suspension gear was specially designed to allow the lamps to be independently and rigidly suspended inside the lantern, while the lantern itself is free to swing slightly and swivel round. In both cases—namely, in the base of the lamp-posts, and in a box fixed to the wall under the bracket—an absolute cut-out switch on an incombustible insulating base, approved by the Board of Trade, is provided. Each contractor has his own form.

In connection with fixing the posts, more difficulty than might be expected was found. The base-plates below the ground could not be by any means uniform in pattern. It was impossible to tell before the ground was opened whether the posts could be solidly supported by a deeply-set base, or by one that spread out under the ground. In erecting the posts extra expense was incurred through having to open the ground a second time after the trench for the mains had been made. The Commissioners were responsible for this, owing to delays in approving of the patterns, and in finally deciding on the actual points to place each post. Several forms of modification of these conditions had to be provided for. In some cases heavy masonry and concrete had to be cut through and replaced. Of the 371 arc lamps contracted for in the eastern and central districts, in March, 1892, the positions of 340 only had been decided on. Of the 340 points 37 were brackets. The weights and costs of these posts, above-the-ground brackets, and lanterns are as follows :

A large base weighs 9cwt., 2qr., and costs	£6	0	0
A small base weighs 6cwt., 3qr., and costs	4	10	0
Each shaft and lantern gallery weighs 3cwt., 1qr., and costs	1	18	0
Each lantern weighs 3qr., and costs	7	0	0
Each bracket weighs about 1cwt , and costs	2	2	0

The contracts with the Commissioners provide for the substitution at 906 points of incandescent lamps of not less than 200 watts* for gas lights throughout the City where arc lights have not been put up. It may here be stated that as early as 1888 every point in the City where arc or incandescent lamps would be likely to be required had been surveyed and plotted under my superintendence. The deviation from that design has been very small.

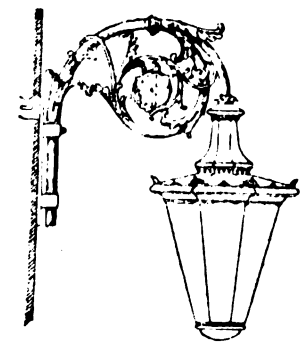

FIG. 24.—Side View, Lantern and Bracket.

The contracts with the two manufacturing companies specified that they are to supply and erect 100 and 200 watt series incandescent lamps ; all arrangements in connection with the first installation to be experimental. The carrying out of these arrangements are still in the experimental stage. The Commissioners had the power to compel the company to complete them in the eastern and central districts by May last ; but in withholding their engineer's order to have this done they have, I think, acted wisely in the interests of public lighting by incandescent lamps.

FIG. 25.—Lantern and Bracket, perspective, and Pipe under, etc.

At the beginning of this paper I stated that the experiment on the Holborn-viaduct in 1882 had brought discredit on this means of public street-lighting. The experiment now going on by the City Company in Basinghall-street is, I think, only calculated to produce the same result ; but it is to be hoped that the Commissioners will be as well advised in this matter as in the past. The principles detailed by Mr. Trotter in his admirable paper before the Institute of Civil Engineers on public lighting by electricity are equally applicable in the case of incandescent lamps as in that of arcs. His dioptric lantern, which we have known ever since

* The prices to be paid by the City for incandescent lamp lighting is (sunset to sunrise)—for a lamp of 200 watts, £10 per annum ; for 100 watts, £5 per annum.

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the days of the Inventions Exhibition, is the mathematical example of that for which he contends. It is many years since, at the Society of Arts, in a paper on incandescent lamps, I demonstrated that the exposure of the filament to the eye, or the eye to the filament, is an abomination. I do not attempt to supplant Mr. Trotter's originality by showing a sketch of a street lantern with a hood, and inverted truncated glass cone underneath, the glass being cut up throughout a zone of its surface into diamond-pattern facets. There is nothing geometrical in their form (though there might be). They are only intended to intercept the direct view of the filament, within an

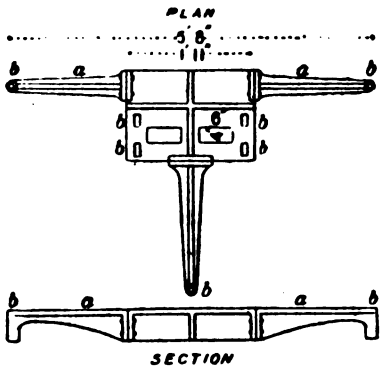

FIG. 26.—Underground Base of Lamp-post.

area of space outside the lantern, and diffuse the rays of light from it. The simplicity of the design as regards convenience, etc., will, I hope, commend itself to the Commissioners; and I believe that if posts in the small thoroughfares and courts were made entirely to disappear, and light ornamental brackets, with lanterns, such as I have illustrated, were used, the City would in this respect have also taken the lead and have set a good example to all other municipal bodies.

This paper, as it title shows, only deals with a portion of the great work of lighting the City of London. Necessarily, my duties as engineer up to July, 1892, required my superintendence of the starting of many works at present far from completion; and while in every case I have been careful to avoid enlarging on matters which could be better described by the engineers more directly responsible, obviously there are also several matters which might be regarded as more or less confidential. These I have

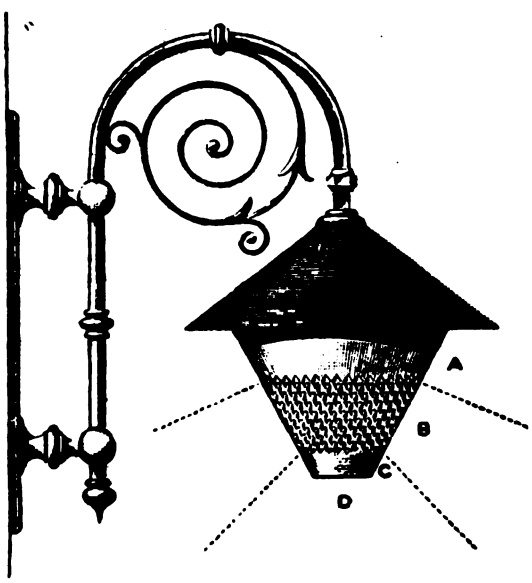

FIG. 27.—Wall Bracket, Incandescent Lamp Lantern.

avoided, and in selecting illustrations from figures have confined myself to those previously accessible to the profession. In concluding, I hope I may be allowed to state that never was an engineer better served than I was by my staff, and that each and all fully justified their selection, equally those who were new to me and those who were old friends. It is no flattery to them to believe that my severance from the position of being their chief has in no way lessened the value of the services which they have since rendered to the shareholders of the City of London Electric Light Company.

DISCUSSION.

Mr. Tasker, who opened the discussion, said that they were all indebted to the author for bringing the points together from a new aspect altogether. It was wonderful that the immense amount of work done had been accomplished in such a short time, and all those who knew anything about the laying of electric light mains would appreciate the difficulties met with in the City.

Mr. G. Kapp remarked that he hardly felt competent to discuss the paper at such short notice because it contained a large amount of difficult matter. He had hoped that the reading of the paper would have lasted until half-past nine, so that they would have had a fortnight to consider the matter and then discuss it. The author had, however, cut out a lot, and had precipitated the discussion. He had also given a large amount of information as to the way he had designed the distributing plant, but he (the speaker) would like to know something about the working of the distributing plant. For instance, one of the illustrations, representing a transformer station, showed the transformers arranged in a two-storeyed building sunk in the ground. The transformers were lowest. He would like to ask what would happen in case water got in. The switchboards were high, but it was doubtful whether they could rely upon the tightness of the casing. Had a method been found of preventing that danger? Another point concerned the various systems of mains used. With regard to the sheathed cables, it was extremely difficult to screen magnetic action, especially if the steel was as thin as No. 22 gauge. The screen would soon be eaten away and the screening effect would be lost. Another point was the question of incandescent lighting in the streets. The author seemed to rather cast a doubt upon the practicability of lighting streets by incandescent lamps. It seemed, however, to the speaker, after all, that incandescent lamps were the right kind of lamps for small streets. When they considered that arc lamps cost at least £25 per annum to keep up, and that a good many arc lamps were required to light a mile of streets, it was an enormous expense, and the expense could only be borne in such parts of the City where the traffic was very heavy, but in all other parts the expense of arc lighting was out of all proportion to the advantages. What they wanted was not a very strong light, but one generally distributed in the streets, and he thought that the incandescent lamp was the right lamp. Moreover, the expense of lamp-trimmers was avoided, and that was a very serious item when many lamps had to be looked after.

Mr. W. B. Esson was of opinion that the paper was more statistical than technical. Like Mr. Kapp, he would like to hear something about the endurance of the distributing work, and also about the watching of sub-stations. There was little given of the actual working of the City lighting.

Mr. Alex. Siemens said that there were some statements in the specification which appeared to him to be entirely against the accepted facts of their profession. The author had told them that the consumption of coal per kilowatt with continuous current was 7lb., and that it did not exceed 5lb. with alternating current. Now that was directly contrary to the results that had been obtained with the use of continuous currents, which could be produced at a cheaper rate than alternating current. It would be interesting to hear some remarks on that point. With regard to telephone wires being protected from interference by the use of iron sheathing, according to the speaker's mind, twin telephone cables (metallic circuits) did not need any protection—they protected themselves against induction. It was almost invidious for him to say a word in favour of lead-cased cables, and he was only doing so because the other lead cable makers seemed to be absent. With regard to the conduits, he thought he would prefer laying lead-covered cables which could be threaded about, under and over gas-pipes and other obstructions without any difficulty. Then again, very great precautions against explosions of gas had not to be taken, because the gas could not get there.

Mr. Braithwaite, in the course of a few remarks, took exception to certain references made by the author in regard to preliminary expenses in connection with the City company.

Mr. J. F. Albright endorsed the remarks made by Mr. Braithwaite. He had had experience in trying to get carried out schemes of that kind, but if preliminary expenses were to be avoided the projects could not be dealt with. He thought there should be no question among engineers that a certain amount of that kind of financing was justifiable. The author of the paper appeared to be rather hard on the incandescent lamp for public street-lighting. When the incandescent lamp was well used, it was undoubtedly a suitable lamp for street illumination. He did not agree with the policy of adopting the Callender-Webber cable system to such a large extent. He believed the best system before them was that of wrought-iron pipes with first-rate insulated cables drawn in.

Prof. Silvanus P. Thompson stated that the abstracts which the author had given of his views did not contain the whole of his views. He did not wish to impute any unfairness in the matter, but as the reports referred to were not his property he was naturally debarred from referring to them. There were certain opinions of his quoted, and which might be fallacious. He might report that the correct thing for electric lighting was vertical engines with direct current. Well, his opinion on that point might be worth nothing. He gave that opinion for a particular station and for a particular district. His view given for a particular district might not apply to another district, when a convenient site could be had for nothing. He was not at liberty to reply to the opinions he had given concerning the use of incandescent lamps for street-lighting. It appeared to him that it was largely a question of the way in which the lamps were used. He wished they could point to more experience of series lamps in incandescent lighting. There were many cases in large, and particularly in small towns, where arc lighting was not the right thing, and where every arc gave far more light than was wanted. A larger number of smaller lamps would be obviously the right thing. With respect to the use of dioptric shades, they all know how the City Company had carried out the attempt to diffuse the light by means of such shades. That was a subject which might claim a special discussion itself. One thing could be done in this way by the use of proper shades—namely, abolish for ever the dark shadows under the arc lamp.

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Mr. R. E. Crompton said that the author had given them the cost of a high-pressure feeder 1,200 yards long at £5,146, and that the annual charge might be put down at £367. He had also contrasted that with the cost of a low-pressure feeder which he made out to be £15,660, and he had challenged him on the matter. Well, he (the speaker) had run the cost out, and made it about £4,400. That was not a mere statement—he was prepared to execute work at that figure. But when he came to maintenance the figures were more interesting. The author had mentioned £161 for paying capital in 21 years at 4 per cent., upkeep and depreciation £136, attendance and small stores £70, or a total of £367. Mr. Crompton, however, from his large experience in the maintenance of mains, knew the expense, and he asserted that there was no trouble in keeping such a feeder in order for £20 a year; the interest and sinking fund would be £130, so that the total cost would be £150, as against £367 mentioned by the author. Was the latter right, and the speaker wrong? He thought in a few years' time nothing but experience would guide them, and the accounts of the company in a few years would show which was correct. Up to the present, however, the accounts of the low-pressure companies showed that it was the lowest and very well maintained. The paper could not be discussed on its merits at such short notice.

Major-General Webber then replied to the discussion. It was true, as Mr. Kapp had pointed out, that the discussion had been precipitated by his having curtailed the paper, but when he had put his thoughts on paper, he found there was more than could be dealt with in the time available. He condensed the paper in reading in accordance with a promise made to the chairman that it should not occupy more than an hour. The question of the screening effect had largely occupied his attention. He believed that the only reason a sound was heard during the experiments referred to, was because the wires were parallel instead of being spirally twisted. It was, of course, necessary to prevent any possibility of disturbing telephone wires in the event of their being laid parallel, and he did not think that they could say that the money spent had been thrown away. Mr. Esson had referred to points against which he (the author) in the paper had guarded himself; the experience of working could only come from those who had had that experience. The paper he had presented chiefly described work the working results of which had been obtained, at the same time confining himself to work designed or superintended by himself. Mr. Siemens remarks about 7lb. and 5lb. were probably due to his not having read the paper with sufficient care. The 7lb. was allowed as a well-known figure, which could not be departed from when it was settled beforehand that the arc lamps were to be run by Brush and Thomson-Houston dynamos, and if any other figures had been put the contractors would not have been prepared to accept it. The 5lb. for an alternating plant was very good, and one which there was every prospect of being able to keep to with regard to the cables adopted, as against lead-covered cables. It was much better to have conduits into which they could draw in fresh cables when necessary, than to be compelled to do as the gas companies did years ago—namely, lay down small pipes and be compelled to replace them by larger pipes. Concerning Prof. Thompson's statements, he (the speaker) did not wish to quote him literally, but at the same time it was natural, with his experience, that he should point to his statements in justification for proceeding with a great work like that. He was glad to hear from Mr. Crompton that his figures had brought out from him a statement of enormous value, but there was one point which he did not answer — namely, whether the £4,400 would construct a conduit which would be found within the sectional area he had given. [**Mr. Crompton** here replied in the affirmative.] The author was only too glad that his paper had been the means of calling forth such a difference in figures.

The **Chairman** then called upon the meeting to propose to the author for his paper a vote of thanks, which was unanimously passed.

LEGAL INTELLIGENCE.

MUIRHEAD AND ANOTHER v. THE COMMERCIAL CABLE COMPANY.

In the Queen's Bench Division of the High Court of Justice, on Wednesday, before Mr. Justice Kennedy without a jury, this action was heard. The plaintiffs, John and Alexander Muirhead and Herbert Arnand Taylor, the patentees and proprietors of certain patents for the system of duplicating cables, known as the Muirhead Duplex System, sued the defendants, a foreign company, incorporated under the United States laws, the owners of certain cables connecting North America and Ireland and Ireland and France, to recover royalties under a written agreement, dated January 2, 1884, giving the defendants a license to use certain patents of the plaintiffs in consideration of a yearly payment of £1,250, to be increased in certain eventualities. The sums claimed were £1,879. 18s. 9d. for royalties from July to September, 1891, and £1,685. 2s. 8d. for royalties from September to December, 1891, making in all a sum of £3,566 odd. The defendants admitted the deed of contract and also a *primâ facie* liability under it; but they alleged that the patents in question had run out at a certain date, and they paid all the royalties due from them up to that date into Court. Thus the defendants undertook the onus of proving that the plaintiffs' American patent of 1880 terminated at the same date as their English patent, by the law in the United States that enacts that "every patent granted for an invention which has been previously patented in a foreign country shall be so limited as to expire at the same time with the foreign patent." In order to establish that contention, it was necessary in effect to show that the plaintiffs' American patent of 1880 was substantially identical to their patent of 1876. The plaintiffs pleaded that such a course was not open to the defendants on the doctrine that a licensee cannot attack the validity of the patent for which the license is granted any more than could a lessee attack his landlord's title though he could show that the lease had expired.

Mr. Finlay, Q.C., Mr. Bousfield, and Mr. E. H. Pollard appeared for the plaintiffs; and Sir Richard Webster, Q.C., Mr. F. S. Moulton, Q.C., and Mr. A. J. Walter were for the defendant company, and Mr. Carpmael held a watching brief for an interested third party.

At the conclusion of the arguments Mr. Justice Kennedy reserved his judgment.

COMPANIES' MEETINGS.

CITY OF BATH ELECTRIC LIGHTING AND ENGINEERING COMPANY, LIMITED.

Directors: T. O. Callender, London, chairman; Alfred Pitman, Bath; B H. Van Tromp, London; C. J. Wharton, London; J. B. Wood, London; Ernest Pitman, Bath. Secretary: Wm. Jeffery, 2, Northumberland-buildings, Bath. Engineer and manager: G. F. Metzger, A.I.E.E.

Report of the directors presented at the third annual general meeting of the Company, held at the works of the Company, Dorchester-street, Bath, on Wednesday, March 7, 1894.

In submitting the balance-sheet and profit and loss account for the year ending December 31, 1893, the directors are pleased to be able to state that the year's working shows a substantial improvement over 1892. The receipts for the current sold are increasing satisfactorily, the total income from this source being £4,621 as compared with £4,301 for 1892. The number of lamps installed has risen from 6,420 to 7,070, and the directors anticipate considerable additions during 1894. The policy of charging by meter only has been steadily pursued—a plan alike fair to the consumer and the Company. The directors have appointed Mr. G. F. Metzger as engineer and manager, and he commenced his duties in May. With his help considerable economies and improvements have been effected, whilst the efficiency of the station and the plant has been fully maintained. These economies have resulted in a profit for the past six months of £464, notwithstanding the additional expenditure involved by the coal strike. Had it not been for a loss on the first six months of £276, and the loss of £277 brought forward from last year, the profit for the year would have been satisfactory. As it is not anticipated that similar losses will again occur, the directors look forward with every confidence to 1894. It may be satisfactory to the shareholders to be informed that the existing machinery and plant are capable of a largely increased output of current without materially increasing the running expenses. The financial position of the Company has also been considerably improved since the last report, and since the closing of the year's accounts the unpaid balance of purchase-money, amounting to £1,242, has been paid. Since the last meeting Mr. E. Garcke, Major-General J. G. Jervois, Mr. H. N. Garrett, and Mr. H. G. Massingham have retired, and the directors have elected Mr. B. H. Van Tromp and Mr. J. B. Wood to the Board. The following directors retire and offer themseles for re-election: Mr. Alfred Pitman, Mr. Ernest Pitman, and Mr. J. B. Wood. The directors waive their fees for the past year.

PROFIT AND LOSS ACCOUNTS.

Dr. *Half-year ending June 30, 1893.*	£	s.	d.
Working expenses, including repairs and renewals of plant and machinery	2,176	6	9
Standing charges: salaries of secretary, engineer, electricians, and other officers, £462. 4s. 8d.; rent, interest, rates, and taxes, £206. 2s. 5d.	668	7	1
Stock, decreased value	64	9	9
	£2,909	3	7

Cr.	£	s.	d.
Proceeds of sale of current and installations	2,547	3	0
Discounts and other receipts	85	17	11
Balance, loss, carried to general balance-sheet	276	2	8
	£2,909	3	7

Dr. *Half-year ending December 31, 1893.*	£	s.	d.
Working expenses, including repairs and renewals of plant and machinery	2,160	11	5
Standing charges: salaries of secretary, engineer, electricians, and other officers, £350; rent, interest, rates, and taxes, £207. 7s. 1d.	557	7	1
Balance, profit carried down	464	4	0
	£3,182	2	6

Cr.	£	s.	d.
Proceeds of sale of current and installations	3,051	17	3
Discounts and other receipts	107	3	2
Stock, increased value	23	2	1
	£3,182	2	6

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BALANCE-SHEET, DEC. 31, 1893.

Capital and Liabilities.	£	s.	d.
Capital—3,834 ordinary shares at £10 each £33,840 0 0			
Less calls in arrear 9 0 0			
	33,831	6	0
Fifty deferred founders' shares of £100 each	5,000	0	0
Mortgages and debentures	3,800	0	0
Creditors—Bankers* 2,019 17 10			
Other creditors 1,650 2 2			
	3,670	0	0
Balance of purchase-money of undertaking (unpaid)	1,242	8	9
	£47,543	8	9

* As security for this overdraft, debentures over the Company's property have been issued to and lodged with the bankers, and these are in addition to the £3,800 mentioned above.

Property and Assets.	£	s.	d.
Property—Site of works £2,000 0 0			
Plant, mains, construction, and sundries: price paid to vendor 29,864 4 3			
Additions 5,613 12 0			
	37,477	16	3
Preliminary expenses	1,296	8	2
Goodwill (founders' shares)	5,000	0	0
Debtors—for current supplied, and installations 2,891 13 1			
Stock, goods on hand 772 8 8			
Cash in office 15 11 1			
	3,679	12	10
Profit and loss—loss in 1892, brought from last balance-sheet 306 15 11			
Less balance of appropriation account, 1891 ..... 29 3 1			
Net loss for 1892 ..... 277 12 10			
Balance brought down, being loss, January to June, 1893 ..... 276 2 8			
553 15 6			
Less balance brought down, being profit, July to December, 1893 464 4 0			
	89	11	6
	£47,543	8	9

The annual meeting was held on Wednesday at the offices in Dorchester-street, Mr. T. O. Callender, chairman of the Company, presiding.

The **Chairman**, in moving the adoption of the report and accounts, said the directors were sorry they could not recommend the declaration of a dividend. They would see from the accounts that the directors had divided them into two half-yearly statements, so that the shareholders could see for themselves the progress of the Company, especially during the latter part of the year. They were not very fortunate during the first half, but in the latter six months their business was, to say the least, fairly satisfactory, and they believed the arrangement that had been made would enable them to conduct their subsequent business on the same lines. They hoped their success would be even greater, and all the Company needed was an extension of the number of customers. He felt it should be a satisfaction to the shareholders to know that the Company's plant was capable of supplying a very much larger number of lamps, that their mains ran past the doors of most houses in the city, that they had laid out the network thoroughly and completely, and that all they now wanted was a larger number of citizens to adopt the illuminant. The directors had found that the old contract system did not work out satisfactory, and the meter system which had been subetituted was considered on all hands to be the fairest and best. Alluding to the accounts, he pointed out that while the revenue of the Company had considerably increased, their expenses remained practically the same. Many alterations had been carried out at the works; Mr. Metzger had been appointed engineer and manager, and the directors were glad to say that with his assistance considerable economies and improvements had been effected. The machinery and plant had also been thoroughly improved, and the station was now in a much better condition than it had ever been. There had been several changes in the board of directors, several having retired, while Mr. B. H. Van Tromp and Mr. J. B. Wood had been elected.

Mr. Van Tromp seconded the motion, which was unanimously carried.

Mr. E. B. Titley moved the re-election of the retiring directors, and the motion was carried. Mr. Butcher was then reappointed auditor, and the meeting terminated.

SCARBOROUGH ELECTRIC SUPPLY COMPANY, LIMITED.

The second ordinary general meeting of the shareholders of this Company was held last week at the offices of the Company, 102, Westborough, Lieutenant-Colonel Steble in the chair.

The **Chairman**, in moving the adoption of the report and balance-sheet, which were given in our issue of the 23rd ult., said that last year at this time the Company had not a brick laid. Now their supply station was in full working order, and two dynamos capable of energising 5,000 lamps were in operation. They had accommodation for five more engines and one boiler when they required them, and therefore they were fully prepared to make the additional supplies of electric light which they might fairly anticipate in the near future. He congratulated the Company on the success it had so far attained, and said that the favour in which the illuminant the Company supplied was held was still spreading. The Company's capital expenditure had been about £20,000. That, he thought, was very small, considering that it included the cost of mains and cables. They had now, he mentioned, 5½ miles of mains, and nearly 18 miles of cables laid. He hoped that before very long they would require more machinery, and if that were so they would require more capital. It would be for the directors to consider how it should be raised, and it might be that they were to issue a certain number of debenture to cover the cost of additional machinery, mains, and cables. He was looking forward with some confidence to the day when electricity would not only benefit Scarborough and the Company materially, but also benefit the health of the borough. In saying that he was thinking of the experiments which were now being made in utilising town refuse for the generation of electricity instead of coal, and anticipated a favourable result. If the experiments should succeed, and the Company could generate electricity in that way, the Company would of course be able to supply the light at a much cheaper price than they were doing now. Already, however, the Company were not charging consumers the prices they were entitled to and which they charged during the first five weeks of the Company's existence. They were now charging from 5¾d. to 6½d. per unit, less 5 per cent. discount on accounts settled within a reasonable time, and that was most reasonable compared with the prices of many other companies.

Mr. A. A. Campbell Swinton, who seconded the motion, said that the question of dividend was the one that probably interested the shareholders most. The receipts amounted now to £125 per month, and just about balanced the expenditure. With the addition of 2,000 or 3,000 more lamps, therefore, the Company would be in a fair way to paying a dividend. It was difficult, however, until they had been working one year to make accurate calculations. The machinery at the Company's generating station had been working satisfactorily. They had had less difficulties than many other companies, and they had got over them more quickly. The amount expended on capital almost exactly corresponded with the original estimates, the only difference being that they had laid rather longer mains than they planned.

The motion was then put to the meeting and adopted.

Mr. G. L. Beeforth, the Hon. C. A. Parsons, and Mr. G. Alderson-Smith were re-elected directors, and Mr. C. E. Bradley was reappointed auditor.

YORKSHIRE HOUSE-TO-HOUSE ELECTRICITY COMPANY, LIMITED.

The ordinary general meeting of the shareholders in this Company was held on Tuesday at the central electric lighting station, Leeds, Mr. Grosvenor Talbot, chairman, presiding.

The **Chairman**, in moving the adoption of the report and balance-sheet (which were given in our last issue), said that since the meeting in May last the directors had not only had a busy and laborious time, but also a time of considerable anxiety. Fortunately they were able to show a profit for the eight months of £1,155, and that, he believed, was very different from what most electric lighting companies had been able to show under similar conditions. The result was all the more satisfactory in that the period covered was the worst of the year so far as the use of electric lighting was concerned. The directors had thought it better to at once reduce the sum expended on preliminary expenses, and had applied £1,000 of the profits to the £2,185 disbursed in those expenses. A similar sum would not be put aside another year, because allowance would have to be made for depreciation, which had not been done this year because the plant of the Company was all new. The Company had encountered two difficulties during the year, one being the unusually bright winter and autumn, and the other the coal strike. Still, they had found it necessary to increase the capacity of their works in order to keep pace with the demand for electric lighting on the part of their customers. In Leeds there was a larger proportion of lamps burning at one time as compared with the number of lamps installed than in almost any other district. The directors had found it absolutely necessary to make provision for an increased demand next winter, and were enlarging the capacity of the engines from 1,100 h.p. to 1,800 h.p. They had made the Corporation an offer to supply the City Hall and Municipal Buildings with electric light at a price which they believed to be considerably within the cost now incurred by the Corporation according to the latter's published accounts. They had also decided to reduce the price of the light per unit 12½ per cent., so as to encourage its use by the general body of consumers, and as the demand increased they would be able to make still further reductions He had the greatest confidence that they would be able to establish a large, thriving, and profitable electric lighting establishment. Electricity was evidently going to be the light of the future, and the only wonder was that the Company should have been allowed to have the opportunity of such a valuable opening as they now possessed of supplying the light to Leeds. He hoped they would avail themselves of that opportunity by doing their best for the citizens.

Mr. Crowther seconded the resolution, which was carried.

Messrs. Crowther and A. G. Lupton were re-elected directors, and Mr. John Gordon, jun., was reappointed auditor.

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COMPANIES' REPORTS.

HOVE ELECTRIC LIGHTING COMPANY, LIMITED.

Directors: Colonel A. J. Filgate, R.E. (chairman); Colonel H. Wood, C.B. (vice-chairman); Harold A. Hoare, Esq.; Carleton F. Tufnell, Esq.; John Wilkes, Esq. Engineers: Messrs. Crompton and Co., Limited. Secretary: Francis R. Reeves, Esq.

Report of the directors to be presented at the annual general meeting of the shareholders at the Town Hall, Hove, on Wednesday, March 14, 1894.

The directors beg to submit to the shareholders the statement of accounts and balance-sheet made up to December 31, 1893, in the form prescribed by the Board of Trade. The statement herewith covers the whole period since the formation of the Company in August, 1892, and is intended to supersede the interim statement submitted to the members on December 12 last. The directors have pleasure in again congratulating the shareholders on the progress of the Company. The number of lamps attached to the Company's main is now equal to 6,915 8-cp. lamps, and the number of houses has increased to 105. From the accompanying statement of accounts it will be seen that the working of the Company has resulted in a small profit at December 31 last, and from the increasing number of new customers and additional lamps connected each week, the directors look forward with confidence to a very satisfactory profit at the end of the current year. The opposition company, the Brighton and Hove Electric Lighting Company, who are supplying a certain number of consumers in Hove with electric current from overhead wires, have been directed by the Board of Trade to make certain alterations in their system of conductors, but they have, it is believed, decided to discontinue their operations in Hove altogether, and consequently your directors expect a large accession of lights to their system shortly. Indeed, at the present moment they have applications from consumers with nearly 3,000 additional lights. Since the date of the interim report the directors have allotted 756 additional shares, bringing up the total allotted to 4,046 shares, representing a subscription of £20,230, while the capital expenditure amounts to £29,236, and consequently there are large balances due to the contractors and others, in addition to which the Company's further commitments on capital account amount to nearly £13,000. It is therefore necessary that further subscriptions for capital be obtained, and the directors would urge upon the members to subscribe for the balance of the Company's shares, a prospectus of which accompanies this report. Immediate application is necessary, as the directors intend to offer to the public any shares not applied for by the members on or before the 10th inst. Colonel A. J. Filgate and Colonel H. Wood, C.B., retire from the Board by rotation, and, being eligible, offer themselves for re-election. Mr. Robert Payne, F.C.A., the auditor of the Company, also offers himself for re-election.

REVENUE ACCOUNT, YEAR ENDING DEC 31, 1893.

Dr.		£ s. d.
A.—To Generation of Electricity.		
Coal or other fuel, including dues, carriage, unloading, storing, and all expenses of placing same on works	£313 17 7	
Oil, waste, water, and engine-room stores	50 7 4	
Proportion of salaries of engineers, superintendents, and officers, as certified by the engineer	60 18 0	
Wages and gratuities at generating station	296 7 11	
		721 10 10
B.—To Repairs and Maintenance		125 10 0
C.—To Rents, Rates, and Taxes.		
Rents payable	141 2 2	
Rates and taxes	49 19 8	
		186 1 10
D.—To Management Expenses.		
Directors' remuneration, proportion of	175 0 0	
Salaries of secretary, accountants, clerks, messengers, as certified by the engineer	126 5 9	
Stationery and printing	33 6 11	
General establishment charges	83 7 11	
Auditor of Company	10 10 0	
		428 10 7
E.—To Special Charges.		
Insurances		3 6 0
Total expenditure		1,464 19 3
Balance carried to net revenue		77 5 8
		£1,542 4 11

Cr.	£ s. d.	£ s. d.
Sale of current per meter, after providing for bad debts	1,265 18 10	
Public lighting	109 5 6	
		1,375 4 4
Rental of meters and other apparatus on consumers' premises		67 17 9
Rents receivable	61 14 4	
Transfer fees	0 2 6	
Connecting installation, etc.	37 6 0	
		99 2 10
		£1,542 4 11

NET REVENUE ACCOUNT, YEAR ENDING DEC. 31, 1893.

Dr.	£ s. d.
Interest on temporary loans accrued due to date	76 3 0
Balance net profit carried forward	1 2 8
	£77 5 8

Cr.	£ s. d.
Balance brought from revenue account	77 5 8
	£77 5 8

GENERAL BALANCE-SHEET, DEC. 31, 1893.

Dr. Liabilities.	£ s. d.
Capital account	21,700 0 0
Sundry tradesmen and others, due on construction of plant and machinery, fuel, stores, etc., to December 31, 1893	8,773 11 3
Consumers' deposits	12 10 0
Net revenue account, balance at credit	1 2 8
	£30,487 3 11

Cr. Assets.	£ s. d.
Capital account—amount expended for works	29,236 6 0
Stores on hand December 31, 1893: coal, £2. 15s.; oils, waste, etc., £7. 5s. 2d.; general, £8. 17s. 7d.	18 17 9
Sundry debtors for current supplied to December 31, 1893	864 1 4
Other debtors for rent	33 10 0
Cash at bankers: Messrs. Barclay and Co., £103. 9s. 7d.; Messrs Hall, Bevan, and Co., £208. 16s. 7d.; cash in hand, £22. 2s. 8d.	334 8 10
	£30,487 3 11

BIRMINGHAM ELECTRIC SUPPLY COMPANY, LIMITED.

Directors: Henry Buckley, chairman; Geo. S. Albright; J. F. Albright; G. H. Johnstone; Francis W. V. Mitchell; J. C. Vaudrey, managing director.

Report of the directors submitted to the shareholders at the ordinary general meeting of the Company, held at the offices of the Company, 14, Dale-end, Birmingham, on Thursday, March 8.

Your directors have pleasure in presenting their fourth annual report and balance-sheet. The amount of net profit, including the balance of £264. 1s. 8d. carried forward last year, is £5,247. 16s. 8d.; out of this the directors recommend the payment of a dividend of 4 per cent., absorbing £2,715. 6s. 7d., placing £1,872. 18s. 1d. to the credit of the depreciation reserve fund, and a further sum of £250 towards the general reserve fund, and carrying forward the balance, £409. 12s, to next year's account. The capital expenditure during the year amounts to £5,356. 10s. 9d., and includes the addition of one new steam-engine and dynamo machine, and further extension of the Company's mains and services. The total number of 16-c.p. lamps or their equivalent on order on December 31, 1892, was 8,329, and on the same date in 1893 the number was 10,223. The demand for the light still continues to increase, and the additions since the close of the financial year bring the total up to 11,034. The directors venture to think that the progress made during the year that has passed will not be considered unsatisfactory, taking into consideration the depressed condition of trade, the prolonged coal strike, and the phenomenally clear days throughout the winter months. At the last annual meeting your directors reported that they considered, owing to the demand for the light in some of the outlying districts, that it would be an advantage to the Company to extend its operations to Edgbaston and the jewellers' quarter. The necessary statutory notices have been given, and a draft of the new provisional order for the additional areas is now under discussion with the Corporation. In accordance with the articles of associations, two directors, Mr. Henry Buckley and Mr. J. F. Albright, retire by rotation, and being eligible offer themselves for re-election The auditors, Messrs. Sharp, Parsons, and Co, also retire, and being eligible offer themselves for re-election.

BALANCE-SHEET, DEC. 31, 1893.

Dr. Capital and Liabilities.		£ s. d.
Capital registered—viz, 200,000 shares of £5 each		100,000 0 0
Capital issued		100,000 0 0
Capital called up—viz.:		
10,000 shares, £5 per share		50,000 0 0
10,000 shares, £2 per share		20,000 0 0
20,000		70,000 0 0
Sundry creditors		3,454 10 10
Depreciation—reserve fund as at December 31, 1892	£1,636 15 7	
Add additions to date	1,872 18 1	
		3,509 13 8
General reserve		250 0 0
Profit and loss account:		
Balance from December 31, 1892	264 1 8	
Profit one year to date	4,983 15 0	
	5 247 16 8	
Deduct amount applied to depreciation reserve	1,872 18 1	
		3,374 18 7
		£80,589 3 1

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Cr. Property and Assets.	£	s.	d.
Freehold land and buildings in Dale-end, and cost of Albert-street lease as at December 31, 1892, £14,401. 10s. 8d.; outlay on buildings to date, £82. 4s.	14,483	14	8
Mains, machinery and plant, furniture and fittings, meters and electrical instruments as at December 31, 1892; £49,170. 16s.; add outlay to date, £5,274. 6s. 9d.	54,445	2	9
	£68,928	17	5
Cost of provisional orders £3,555 13 1			
Expenses on account of additional area 181 11 8			
	3,737	4	9
Preliminary expenses	1,685	2	4
Cash in hand and with bankers	2,479	16	10
Sundry debtors	2,949	4	0
Stock of stores and work in progress as per signed stock book	808	17	9
	£80,589	3	1

BUSINESS NOTES.

Great Northern Telegraph Company.—For the month of February the receipts were £20,000

Hobart Electric Tramway Company.—For the month of February the receipts were £1,431.

Western and Brazilian Telegraph Company.—The receipts for the week ended March 4 were £3,001.

Change of Address.—The address of Mr. Robert Hammond is now Ormonde House, Great Trinity-lane, E.C.

Canterbury.—A meeting of the Town Council will shortly be held to consider the question of electric lighting.

Hartlepool.—The Corporation decided on Tuesday to defer *sine die* the question of introducing the electric light.

Liverpool Overhead Railway.—The traffic receipts of this railway for the week ending 4th inst. amounted to £635.

Cuba Submarine Telegraph Company.—For the month of February the receipts were £165 less than for the corresponding period of 1893.

Eastern Telegraph Company.—The receipts for the month of February were £54,904, as against £55,281 for the corresponding period of 1893.

Eastern Extension Telegraph Company.—For the month of February the receipts show a decrease of £4,346 as compared with the corresponding period of 1893.

Tenders for Lighting Tramcars.—The Glasgow Corporation, as will be seen from our advertisement columns, invite tenders for the electric lighting of 240 tramcars.

West India and Panama Telegraph Company.—The receipts of this Company for the two weeks ended February 28 were £111 less than for the corresponding period of 1893.

Tender Accepted.—The tender of Messrs. S. Dixon and Son, of Boar-lane, Leeds, has been accepted for lighting the Dewsbury workhouse and premises by electricity, for the Guardians.

Crewe.—On Saturday last a fire broke out in the electric accumulator-house at Crewe Works. Considerable damage was done to the buildings, and nearly all the acid-tanks were broken by the heat.

York.—Mr. Arnold Taylor has conducted an enquiry with reference to further borrowing powers sought by the Corporation. The loans include the sum of £350 for the electric lighting of the public library.

Personal.—Mr. H. M. Sayers, now superintending engineer of the Companhia de Luz Electrica, Oporto, has been appointed superintending engineer of the Bournemouth and District Electric Supply Company.

Brazilian Submarine Telegraph Company.—The directors have declared an interim dividend of 3s. per share, or at the rate of 6 per cent. per annum, free of income tax, for the quarter ended December 31 last.

Edinburgh.—The Corporation Electric Lighting Committee have agreed to charge for electricity 6d. per unit for lighting, and 3½d. per unit for motive power. This proposal has been adopted by the Corporation.

Latimer Clark, Muirhead, and Co., Limited.—Mr. Justice Vaughan Williams on Wednesday made an order that the voluntary winding-up of this Company should be continued under the supervision of the Court.

Traction at Newcastle.—The Newcastle City Council on Wednesday, at the request of the Special Tramways Committee, sanctioned the expenditure of £300 in gathering information as to the various systems of traction.

Chelmsford.—At a meeting of the Town Council last week the Lighting Committee presented an estimate for the lighting of the borough for the ensuing 12 months. The total cost would be £995, with £5 additional for lighting the public clock.

The Tenders for Bury.—To-morrow (Saturday) is the last day for sending in tenders required by the Technical School Committee of the Corporation of Bury for the supply of electric light fittings, including switchboards, lamps, wiring, etc., for lighting the technical school.

Halifax.—The Gasworks and Electric Lighting Committee have decided to buy 70 yards of land situate on the west side of the electric lighting station site, from the Vicar of Halifax at 23s. 3d. per yard, and 87 yards of land adjoining from Mr. Alfred Bancroft at 25s. per yard.

Bolton.—Messrs. Dobson and Barlow, Limited, of Bolton, have placed with Messrs. Lowcock, Hill, and Co., of Manchester, the order for the lighting of a portion of their machine-shop with 120 inverted arc lamps, and also a large extension of their incandescent installation with dynamo.

Messrs. J. Stone and Co.—We understand that the well-known firm of Messrs. J. Stone and Co., sanitary and general engineers, of Deptford, S.E., have recently opened an electrical department, and that they are devoting considerable attention to the electric lighting of trains and of steamers.

City of London Company's Debenture Stock.—The applications for the £100,000 5 per cent. debenture stock of the City of London Electric Lighting Company, Limited, which has just been issued, amounted to £1,288,835. The letters of allotment and regret were posted on Wednesday evening.

Tenders for Blackpool.—The trustees of the United Methodist Free Church, Adelaide-street, Blackpool, invite tenders for fitting up the church with electric light. Parties tendering to furnish their own designs. Information respecting same may be obtained from Mr. George Johnson, 16, South Beach, Blackpool

City and South London Railway.—The receipts of the Company for the week ending March 4 were £934, against £929 for the same period last year, or an increase of £5. The total receipts for the first half-year of 1894 show a decrease of £128 compared with those for the corresponding period of 1893.

Oswestry.—It was mentioned at a meeting of the Town Council on Monday that the deputy town clerk and Councillor Spoull had attended on February 17 at the Board of Trade office with regard to the electric lighting of Oswestry, and that the Board were satisfied as to the stability of the electric lighting company.

Proposed Electrical Exhibition at Derby.—Mr. Marsden proposed, at a meeting of the Town Council on Wednesday, that an electric lighting exhibition should be held at Derby, and that the Electric Lighting Committee be empowered to spend £200 on the project. Mr. Leech seconded the motion, which was carried.

Chatham.—At a meeting last week of the Town Council the Mayor gave notice of his intention to move that the local electric light and power company should be asked to state the terms upon which they would be prepared to supply current to electric tramcars upon a route extending from the Luton Arch to Star-hill.

United Asbestos Company, Limited.—The directors of this Company recommend the payment of the following dividends for the past year: 10 per cent. on the £10 preference shares, 6 per cent. on the £5 preference shares, and 2½ per cent. on the ordinary shares, carrying forward a balance equal to 5¾ per cent. on the ordinary shares.

Tenders Wanted for Brighton.—The Town Council of Brighton invite tenders for the supply and laying of armoured and lead-covered electric cables. Specifications can be obtained on application at the office of Mr. Francis J. Tillstone, town clerk, Town Hall, Brighton. Sealed tenders must be left at his office by Monday, March 12.

Tenders Required for Leamington.—The Corporation invite by Monday, the 12th inst., tenders for the erection of five short lines of telephone wires, and for the provision and fitting up of six sets of telephonic apparatus complete in all respects. Plans and specification may be seen at the office of Mr. de Normanville, the Corporation engineer, at the Town Hall.

The Harrogate Tenders.—It may be well to remind intending contractors that next Wednesday is the last day for sending in tenders invited by the Corporation of Harrogate for refuse sorting and drying plant, with accessories, steam-boilers and accessories, steam and exhaust pipes, transformers and accessories, and distribution mains for the proposed central station.

National Telephone Company.—The staff dinner of this Company took place last week at the Holborn Restaurant, under the presidency of Mr. E. L. Gaine (the general manager). There were 200 gentlemen at dinner, including Sir A. K. Rollit, M.P., Mr. A. Anns (the secretary), Mr. Dane Sinclair (engineer-in-chief), Mr. G. H. Robertson, Mr. W. A. Smith, Mr. J. Ardrons, Mr. C. S. Agnew, Mr. R. W. Wallace, etc.

Dover.—The Town Council last week received a letter from the Board of Trade in reference to the representation which had been forwarded them on their electric light regulations, stating that they had given the matter careful consideration when the regulations were drawn up, and that they could not see their way to make any alterations. They also pointed out that overhead wires were not allowed without their express permission.

Glasgow.—At a meeting of the Town Council last week Bailie Primrose called attention to the defective electric lighting in the City Hall. Bailie Pettigrew explained that the committee were satisfied that the system of lighting in the hall was all that could be desired, but the lamps at present in use had been put up only temporarily, and when the new lamps were fitted up the objection which Bailie Primrose urged would be entirely removed.

Maidstone.—It will be remembered, as stated in our issue of 23rd ult., that the question of entrusting Messrs. Bourne and Grant with carrying out the electric lighting order of the Local Board, was adjourned from the last meeting for further consideration. Alderman Ellis last week again formally moved that the committee's report be adopted. Mr. Baker seconded, but after some discussion the matter was again adjourned for a fortnight.

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The Strand.—The District Board of Works have resolved that the report of the Works Committee on the subject of improving the lighting of the Strand district, at a sum not exceeding the amount mentioned in the surveyor's report presented at the last meeting, be adopted on its further consideration by the committee with certain suggestions made by the proposer of the resolution.

The Tenders for Edinburgh.—Saturday, the 17th inst., is the last day for receiving tenders required by the Corporation of Edinburgh for the following work in connection with electric lighting: construction of concrete culverts and laying of stoneware and iron pipes and casings; supply of cast iron pipes, casings, and road service boxes; supply of stoneware casings and insulators; supply of copper strip; and supply of armoured and unarmoured insulated cable.

Fleetwood.—At a meeting last week of the Improvement Commissioners, Mr. Hudson mentioned that there was a correspondence going on in various journals respecting the merits of certain dynamos worked in parallel in connection with electric lighting stations. It was thought desirable the Board should await the results of the working of these dynamos at certain places, and the Electric Lighting Committee were empowered to visit several places, if required, to inspect.

Burnley.—At a meeting of the Board of Guardians, Mr. Thompson raised a discussion on an expenditure of £45 for providing electric lighting fittings to the union offices, and contended that the resolution passed at the last meeting was out of order, as no notice had been given. The clerk informed him that the resolution was perfectly in order. The question was referred to the Finance Committee for consideration, and they brought forward a recommendation, which the Board adopted.

Grange.—The chairman to the Local Board, having ascertained from the clerk that the cost of obtaining a provisional order would be about £250, which was a much larger sum than he had anticipated, has withdrawn his motion for applying for such an order. At the same time he feels strongly that they should not lose much more time before going into the question of the cost of the lighting of Grange, his own opinion being that some system of electric lighting would be much cheaper and better than the present costly system. He hopes, therefore, the question will not be lost sight of.

Tenders Required for Sutton.—The Sutton (Surrey) Local Board invite tenders for the purchase of their powers granted to them by the Board of Trade under the Sutton (Surrey) Electric Lighting Order, 1892, for the lighting of the district comprised in the provisional order. The system proposed to be adopted is the low-tension system. All further particulars can be obtained of the Board's surveyor, Mr. A. D Greatorex, C.E, and copies of the specification and proposed deed of transfer may be obtained at his office at a charge of £1. 1s. Tenders should be addressed to Mr. Thos. D. Pettiver, clerk, Local Board Offices, Public Hall, Sutton, Surrey, by April 4.

Edinburgh Corporation Electrical Engineer.—The Electric Lighting Committee of the Town Council have selected for decision the following gentlemen to be recommended to the Town Council from the 98 applicants for the post of electrician to the Corporation: Mr. R. A Chattock, Metropolitan Electric Supply Company, Limited, Amberley-road station, London; Mr. George B. Dunn, Metropolitan Electric Supply Company, Sardinia-street station; Mr. E. W. Monkhouse, M.A, Westminster Electric Supply Corporation, Limited, Eccleston-place. On Tuesday the Corporation appointed Mr. Monkhouse resident electrical engineer at a salary of £300 per annum.

Morecambe Electric Light and Power Company.—The third annual meeting was held last week, Mr. C. Mabbott presiding. The report showed an expenditure on revenue account of £1,361 and receipts £1,546, leaving a gross profit of £185. The subscribed capital had advanced from £2,782 in 1892 to £5,640 in 1893 the debenture capital from £1,000 to £1,500, expenditure on plant, cables, etc., from £4,317 to £7,250, gross revenue from £577 to £1,281, number of lamps fixed from 1,200 to 2,400, 832 new shares had been issued since the end of the year, and of the 500 shares for the Sandylands extension 370 had already been taken up. The report was unanimously adopted, and a dividend of 2 per cent. declared.

Messrs. Rashleigh Phipps and Co.—This Company, of 102, Oxford-street, are at present engaged upon the installation of nearly 1,000 additional lights at Messrs. Marshall and Snelgrove's large premises in Oxford-street and their new premises in Vere-street. A complete plant is being established to run these additional lights, large additions to the present engine-room having been effected to accommodate the two engines and dynamos and four sets of accumulators. This firm has also recently completed an installation of some 300 lights for the Hon. H. Sturt, M.P., at his new house, 38, Portman-square, with great success; they are also engaged upon the lighting of some 20 other private houses in various parts of London and district.

An "Electrical" Bazaar.—On Wednesday Lady Randolph Churchill opened an "electrical" bazaar, promoted by the Bradford and District Teachers' Association, in the Technical College, Bradford. The lecture hall of the Technical College is given up for sale purposes, and presents a brilliant spectacle. The windows are darkened, and from the decorated stalls incandescent lights glow by day as well as in the evening. In the centre of the hall is an Eiffel tower, lighted from within by incandescent lamps. The other rooms are similarly treated, while from the cupola of the college at night a 15,000-c.p. search-light serves as an advertisement. The installation has been carried out by the Wray Electric Engineering Company, of Bradford,

Derby.—At a meeting of the governors of the Derbyshire Royal Infirmary, the Building Committee reported that they had had under consideration the necessity for entering into a contract for the provision of electric light for the four large and four small wards now nearly completed. Colonel Buchanan moved the adoption of the report. He stated that the committee would use the electric light for the present on a small scale in those parts of the institution where it was essential that everything detrimental to health, even in the smallest degree, should be excluded. Sir John Smith seconded the adoption of the report, which was carried. It was decided to invite estimates for the work.

Longitudinal Wedge Seam Joint Steel Tubes.—This tube has been patented by Mr. Frank Williams. It is claimed that it can not only be supplied at less cost than riveted steel tubes, but it can also be made to stand pressures up to 800lb. per square inch. The tubes can be shipped in plates ready to be put together at their destination at little cost, and effecting, it is said, a great saving in freight on foreign orders. These tubes can be made in any lengths consistent with the rolling of the plates, and to almost any diameter, with special or ordinary couplings to suit requirements. They are manufactured by Messrs. Frank Williams and Co., Eagle Works, Wolverhampton, whose London agent is Mr. Henry Pynegar, 5, Dowgate-hill, E.C.

The Glenburn Hydropathic Establishment at Rothesay.—The new Glenburn was formally inaugurated last week. In addition to a full supply of gas, which can be used when necessary, the electric light has been fitted throughout the establishment. Messrs. Claud Hamilton, Limited, of Glasgow, who have lately carried out the electric lighting of the Theatre Royal, Glasgow, and other important work in the Royalty Theatre, Glasgow, and Lyceum Theatre, Edinburgh, for Messrs. Howard and Wyndham, were the contractors with regard to the generating plant. Steam is supplied from one of two Cornish boilers at 80lb. pressure to two of Ransome's high-speed vertical double-acting engines. The engines each drive by belting a compound dynamo.

Londonderry.—The Electric Lighting Committee of the Town Council met on Tuesday to appoint an electrician to take charge of the works. There were 71 applicants for this office. The Corporation had invited Messrs. Siemens to select the three most eligible from that number. The first of these was John Christie, age 26, of the Glasgow electric lighting station, who required £180 to £200 a year; the second was H. C. Kromschroeder, Woolwich, age 36, salary £200, progressive; the last was Albert Barnes, age 30, Exhibition-road, South Kensington, S.W., salary £150. Councillor Brewster proposed that John Christie be elected electrician at a salary of £180 a year. Councillor Young seconded the motion, which, after some discussion, was carried.

Eccles.—On Monday, at a meeting of the Town Council, Alderman Kendall moved the acceptance of the minutes of the Electric Lighting Committee and the terms of Prof. J. Hopkinson to prepare a report upon the electric lighting of Eccles, dealing with the position of the generating station, the system to be adopted, and the extent of the installation. Alderman Spary said he did not think the Council would find it profitable to light the borough with the electric light. He should object to any expense being incurred until the Council knew what number of private consumers would avail themselves of the new light. In reply, Alderman Kendall said that the Council had to make a start if they were to comply with the conditions of the order. Before a scheme was adopted the sanction of the ratepayers would be sought. The resolution was carried.

Plant for Sale.—As stated in our advertisement columns, the London and India Docks Joint Committee are prepared to receive tenders for the purchase (including removal from present sites) of the following: four Marshalls multitubular boilers; four Marshalls single-acting engines, with jet condensers; three vertical donkey pumps; 28 cast-iron standards with plummer blocks; four lengths of steel shafting, each 40ft.; 47 dynamos and seven exciters; 179 arc lamps and lanterns; 44 cast-iron pulleys; 54 lengths of leather belting; sundry carbons; two spare travelling bobbins; four spare commutator rings. The whole of this plant can be seen at the Royal Albert Dock. Tenders must be addressed to the Chairman, Works and Stores Committee, by 31st inst. Further particulars and specifications can be obtained on application at the Dock House, 109, Leadenhall-street, E.C.

The Palace, New Brighton.—Messrs. A. Hall and Co., of 1 and 11, South John-street, Liverpool, have secured the contract for the lighting of the Palace, New Brighton. The plant will consist of a 32-h.p. gas-engine, a 100-light machine, and handsome switchboard; these are to be erected in the grotto which is open to the public. In the large hall they are fitting 106 16-c.p. lamps in handsome electroliers, also lighting the theatre and skating rink attached to the Palace. In all there will be 200 16-c.p. lamps and six large arcs, together with the company's patent electrical signboard illumination. In addition to this, Messrs. Hall and Co. have been favoured with a contract for complete electric light installation, consisting of gas-engine, dynamo, and numerous 16-c.p. incandescent and arc lamps, for Mr. W. Boote, of the City Pantechnicon, Elizabeth-street, Liverpool, for whom they had previously put down a successful installation at another of his establishments.

Newington, Priddle, and Co., Limited.—This Company was formed in March, 1893, to acquire the business of electrical and mechanical engineers carried on by Mr. Newington and Mr. Priddle. The nominal capital of the Company was £7,000, and the purchase price for the business was £4,000, payable in shares. Under a winding-up order made last January against the Company, accounts were issued on Wednesday showing debts £1,210.

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19s. 10d., ranking against assets £744. 1s. 4d., and a total deficiency of £6,446. 18s. 6d. to the contributories. The sole right to manufacture and sell the "Phonautograph" was acquired by the Company in May, 1893, and a sum of £500 was advanced to the inventor, to be repaid out of the profits on the sales, but no such sales have been effected. To the lock-up of that £500, and to insufficient working capital, the failure of the Company is attributed.

Liverpool.—It is stated that the Health Committee of the Liverpool Corporation decided last week to adopt a plan by which the refuse burnt at the destructor in the sanitary yard at Chisenhale-street will be utilised for the development of power sufficient te light the yard by electricity. The following resolution passed by the Liverpool Trades and Labour Council, and forwarded by Mr. Charles Rouse, the secretary of that body, was referred on Wednesday to the Watch Committee of the Liverpool Town Council for consideration: "That this meeting of the Liverpool and District Trades and Labour Council urge upon the City Council, in view of the present exorbitant price of gas, to consider the possibility of utilising the tidal force for the generation of electricity, thus improving the lighting of the city at a reduced cost to the ratepayers, the construction of the works also affording employment for some of the surplus labour in the market."

Emmanuel College, Cambridge.—The London branch of Messrs. Mather and Platt, Limited, of 16, Victoria-street, Westminster, have recently completed an electric light installation at Emmanuel College, Cambridge. It comprises a semi-portable engine developing 20 b.h.p., driving an Edison-Hopkinson dynamo having an output of 120 amperes at 140 volts. The college buildings being distributed over a considerable area, special arrangements have been made for the distribution of the current, and the equalisation of potential, and underground cables have been run to various centres. A large set of accumulators, capable of discharging at 120 amperes, has been supplied and erected. The cells are of the Electrical Storage Syndicate's chloride make—a type of battery which is now being introduced into England, and which we described a few months ago. Some 300 lights have been erected in the college, the fellows' and masters' chambers, chapel, and lecture-rooms, etc.

Elmore Copper Companies.—Mr. Edward Reynolds, of Vickers, Sons, and Co., Limited, has joined the board of Elmore's Wire Manufacturing Company, Limited. It is stated that the whole of the recent issue of £30,000 preference shares has been placed. A circular issued to the shareholders of Elmore's German and Austro-Hungarian Metal Company, Limited, states: "Your directors regret that the issue of the 8 per cent. debenture stock, offered to the shareholders in their circular of the 10th ult., has not been taken up. This is unfortunate, as it leaves no alternative but to proceed with the issue of the preference shares referred to in that circular. On the other hand, the directors have pleasure in announcing that a contract has been entered into with the German Imperial Marine for the supply, to the Government docks at Wilhelmshaven, Kiel, and Dantzic, of all the copper tubes between 7in. and 12in. in diameter that may be required for the next three years, and it is imperative that the company be at once put in funds in order to carry this contract into effect."

Cheltenham.—At a meeting of the Town Council on Monday, the Electric Lighting Committee recommended that the tender of the Galloway Company for two boilers at £438. 15s. each should be accepted. They also recommended that the quick-running type of engine be adopted, but before finally deciding on the particular engines and alternators the committee thought it desirable to see and inspect the system in operation at Bristol, and that, subject to such inspection being satisfactory, the tender of Messrs. Siemens and Co., with Willans engines, at £4,610, less £365 for boiler, be accepted. Mr. Ward-Humphreys proposed, and Mr. Woodard seconded, the adoption of these recommendations. Mr. Margrett moved that the whole matter be referred back to the committee for further information, and pending the decision of the Local Government Board as to whether sanction would be given to the necessary loan. Mr. Steel seconded the amendment. Eventually the adoption of the minutes was adjourned to allow of further information being given.

Morley.—On Monday the Town Council adopted the report of the Electric Lighting Committee, which stated that various schemes had been considered, and that the committee had visited the electric lighting works at Bradford, Huddersfield, and Leeds. The result of their inspection of the places and schemes is that, in the first place, they recommended that the premium for the best scheme should be awarded to the author of the scheme marked "Lux et Felicitas." This, on being opened by the Mayor, was found to be that of Mr. Robert Hammond. They believed that a thoroughly efficient service of electric lighting, including the provision of land and the necessary works extending from St. Peter's Church to High-street, and including the branch streets, could be established for the sum of £15,000. The system they recommended was high tension. The committee also asked for power to prepare a more detailed report, and ascertain what loans would be required, and to take steps for obtaining the necessary powers to establish the supply as early as practicable, and this was granted.

Lighting of Monmouth.—A special meeting of the Town Council was held on Tuesday of last week to receive the report of Messrs. Bramwell and Harris on the combined scheme for electric light and drainage in the borough, and particularly the practicability or otherwise of utilising the Wye as a motive power to work the machinery by turbines. The report fully approved of the scheme as set forth in the plans prepared by Mr. Lailey, C.E., and the British Electrical Company. They are of opinion, however, that the site selected for the turbines is not the most suitable in view of the great expense of forming a separate watercourse, and some difficulty which has arisen with the owners of land for purification purposes. Having thoroughly inspected the locality, they recommend that the electric generating station be fixed on a now disused watercourse at the Old Forge on the River Monnow, where a continuous supply of water, with a fall of 9ft., can be relied on all the year round. This arrangement would allow of the sewage pumping machinery being fixed at any convenient place, it being worked by electric motors. After discussion the scheme was adjourned until last Monday. The Town Council then agreed that Messrs. Bramwell and Harris should be requested to advise the Corporation generally upon the proper system to be adopted. The clerk was requested to apply for a provisional order for electric lighting.

The Telephone System in Manchester.—Mr. Alderman Milling, chairman of the Paving and Highways Committee, moved on Wednesday, at a meeting of the Town Council, the adoption of the report of the committee with reference to the arrangements proposed to be made with the National Telephone Company for the laying down of the wires of that company under the streets of the city. He said it would be remembered that on the 7th of last month the Paving and Highways Committee received instructions to negotiate with the National Telephone Company with the view of entering into arrangements with the company to take down their sky wires in the centre of the city and lay them under the streets. A sub-committee was appointed, who had an interview with the officials of the National Telephone Company, when the whole matter was thoroughly gone into. The manager, Mr. Gaine, was told that there was a strong feeling on the part of some members of the Corporation that substantial reductions should be made in the annual subscription in consequence of the consideration which the Company had received. Mr. Gaine, however, said it was absolutely impossible. Out of the £10 a year they received from subscribers £8 went in expenses, £1 went to the Government, and the remainder went in dividend and renewals; and therefore there remained a very small margin indeed for the latter purpose. He added that if that line of policy was pursued the negotiations must collapse, because the company could not for a moment recede from the position they had taken up. With regard to equivalents, the company were prepared to pay to the Corporation a charge of 5s. per annum for each subscriber to the Manchester telephone exchange of the company for the privilege of using the streets for the underground tubes; that the minimum number of subscribers to be charged for would be 3,000, which would result at once in an income of £750 a year. They anticipated that there would be obtained 9,000 subscribers, amounting to a sum of £2,250 a year. Mr. Alderman Milling, by means of plans, described the manner in which the wires would be laid underground, and pointed out that no monopoly would be conferred upon the company, because the Corporation would have full power to make arrangements with other companies if it thought fit. The National Company would be responsible for and would indemnify the Corporation against all damages and accidents. He quoted a list of charges made for telephonic accommodation in various continental cities and in America. These ranged from £9. 16s. per annum in Amsterdam to £39. 11s. in St. Petersburg and £50 in New York. After considerable discussion the report of the committee was adopted.

Electric Lighting of Bury.—At a meeting of the Electric Lighting Committee of the County Council on January 23, it was resolved that Messrs. Crompton and Co. should be added to the list of firms to be askod to tender for the carrying out of the scheme of the committee when prepared, and it was also resolved that the committee visit the stations at Liverpool, Bradford, and Leeds before deciding on the scheme to be adopted. At a meeting on February 12 the report on the visits to Leeds, Bradford, and Liverpool was approved. The following report was presented by the borough engineer: "In accordance with your suggestion, sketch plans have been prepared of the electric lighting station, (1) general plan of site showing position of offices, engine-house, boiler-house, condenser pond, etc.; (2) plan showing accumulator, boiler, and engine house, sufficient for the supply of 7,000 8-c.p. lamps; (3) additions showing building for double the number. The plans provided for direct-driven engines, but if the committee decide to adopt rope driving, the only alteration required will be the extending of the west wall to the street line. As previously decided upon, the system proposed to be adopted is continuous current, medium pressure, with accumulators, and three wires for distributing the energy. The pressure at the lamps is proposed to be 110 volts. Plant is proposed to be erected as a first installation of about 4,000 8-c.p. lamps, but the capacity of the building, as already stated, is such as to allow for 7,000 8-c.p. lamps. The following is a brief description of the proposed buildings and plant. The buildings are divided into four parts: (1) the offices, testing-rooms, showrooms, stores, etc.; (2) the accumulator-room; (3) the boiler-house; (4) the engine and dynamo room. The offices are proposed to be built in two storeys upon the narrow strip of land adjoining the site in Rochdale-road. On the ground floor there will be enquiry and clerk's office, space room, common sitting and locker room for employés, store-room for lamps and materials, fitting and repairs shop, cable terminal room, weigh-house, and storekeeper's room. On the first floor there will be engineer's offices, fitting showroom, experimental laboratory and lamp-testing room, meter-testing room, meter storeroom, electrical testing-room for standard instruments. Under the passage running from end to end of the offices will be the main conduit for conveying the cables from the cable terminals room to the street, and a similar conduit leads from the terminals-room into the

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engine-house and behind the main switchboard. The accumulator-house of special construction without metal as far as possible, and with abundant ventilation, will be fitted with 150 Epstein accumulator cells, fitted to maintain 2,500 lamps for two hours if a total breakdown occurs to the machinery, but will be large enough for double that quantity. The boiler-house to have foundations built for three boilers and a chimney sufficient for six boilers. It is proposed to put down at first two Lancashire boilers, each 30ft. long, 8ft. diameter, for a working pressure of 150lb. per square inch. Steam-pipes to be of wrought iron, with copper bends and connecting pieces to engines. The engine-house to contain, as a first instalment, two engines of 200 i.h.p. each, and one engine of 75 i.h.p., directly connected to slow-speed dynamos. Two dynamos to give an output of 270 volts and 500 amperes. One dynamo to give an output of 280 volts and 200 amperes. The main switchboard to be of enamelled slate to represent green marble, finished in polished walnut mountings. A set of economisers, of Messrs. Lowcock's, Green's, or other approved manufacture. An independent condensing plant of approved make to be placed in the boiler-house. Cables to be of the highest quality obtainable, laid either in cast-iron pipes or troughs, or bitumen or earthenware. All cables to be insulated with vulcanised india-rubber." It was resolved that the report be entered on the minutes, and that plans and specifications be prepared on the lines laid down therein, and submitted to a future meeting of the committee. The Mayor, at a meeting of the County Council last week, moved the confirmation of these minutes. After some discussion, they were confirmed.

PROVISIONAL PATENTS, 1894.

FEBRUARY 26.

4055. **Improved telephone exchange system.** Pierre Emmanuel Emile Raverot and Georges Albert Hess, 1, Rue Boursalt, Paris. (Date applied for under Patents, etc., Act, 1883, Section 103, 8th August, 1893, being date of application in France.)

4083. **Improvements in electric arc lamps.** Karl Schleyder, 323, High Holborn, London. (Complete specification.)

4091. **Appliances for the carbons of electric arc lamps for increasing the duration thereof.** Francis Jehl and Moriz von Hardtmuth, 28, Southampton-buildings, Chancery-lane, London. (Complete specification.)

4096. **Improvements in cable traction operated by electricity as a motive power.** James Lloyd Copping, 1, Queen Victoria-street, London.

4102. **Improvements in street fire-alarms and telephonic combinations for same.** Henry Alfred Charles Saunders and Alfred Charles Brown, Winchester House, Old Broad-street, London.

FEBRUARY 27.

4113. **Improvements in electric batteries.** Harry Theodore Barnett, 14, Narcissus-road, West Hampstead, London.

4142. **Improvements in construction of electrical letters and signs.** Alfred Réné Upward, 150, Holland-road, Kensington, London.

4144. **Improvements in electrodes for arc lamps.** Edgar Oldcott Clark, 55, Chancery-lane, London. (Complete specification.)

4168. **Improved construction of electric battery.** Avando Warren Hussey, 166, Fleet-street, London.

4170. **Improvements in alternating-current electric motors.** William Phillips Thompson, 6, Lord-street, Liverpool. (Charles S. Bradley, United States.)

4171. **Improvements in alternating-current electric motors.** William Phillips Thompson, 6, Lord-street, Liverpool. (Charles S. Bradley, United States.)

4177. **A new or improved reel device for fire hose, electric cables, suspending cords, and the like.** William Phillips Thompson, 6, Lord-street, Liverpool. (Philipp Schneider, Germany.)

4182. **Improvements in overhead electric travelling cranes.** Lloyd Higginbottom, Thomas Mannock, and Edward Hopkinson, Crown Ironworks, West Gorton, Manchester.

4190. **Improvements in apparatus for use with electrically-illuminated signs or advertisements, or in other cases where frequent changes of electric circuits are to be made.** Ernest Lower Berry and Frederick Harrison, 47, Lincoln's-inn-fields, London.

4197. **Improvements in or connected with bases and covers for electric switches and fuses.** Friedrich Wilhelm Busch, Norfolk House, Norfolk-street, Strand, London. (Complete specification.)

FEBRUARY 28.

4214. **Improvements in or in connection with electricity and other meters.** Wilfrid L. Spence, The Elms, Seymour-grove, Manchester.

4226. **Improvements in electric arc lamps.** Rudolf Hermann Jahr and Carl Ferdinand Schoeller, 47, Lincoln's-inn-fields, London.

4235. **A new electric fitting for piano.** John William Ewart, 23, Ampthill-square, London.

4254. **Improvements in electric arc lamps.** John Charles Bond Andrews, 5, Melrose-gardens, London.

4244. **Improvements in and relating to the overhead system of electric tramways.** Alfred Dickinson, 77, Colmore-row, Birmingham. (Complete specification.)

MARCH 1.

4325. **Improvements in the electro-deposition of aluminium.** Alfred Hinton Harris, 128, Colmore-row, Birmingham.

4326. **Lamp, answering the purpose for cap and loop lamp (for incandescent lamps).** Thomas Bamber and Oswald Bamber, 96, Empress-street, Accrington.

4333. **Improvements in and relating to apparatus for supporting and suspending electric light and other like fittings.** William Henry Johnson, Upper Terrace-road, Bournemouth. (Complete specification.)

4353. **Improvements in recorders and reproducers of phonographs.** Alfred Waterman Carter, 22, Glasshouse-street, Regent-street, London.

4366. **Improvements in dynamo-electric machines.** Alfred Julius Boult, 323, High Holborn, London. (Compagnie de l'Industrie Electrique, Switzerland.)

MARCH 2.

4402. **An electricity meter.** Harold George Rea, 22, Cardigan-road, Richmond-hill, Surrey.

4429. **Improvements in and in the manufacture of electrical switches.** Amandus Metzger, 55, Chancery-lane, London. (Complete specification.)

MARCH 3.

4477. **An improved automatic regulator for electric generators.** John Hesketh and Thomas Hesketh, 14, Osbourne-road, South Shore, Blackpool.

4484. **Electromagnetic switching.** George Michaelson, 33, Unter den Linden, Berlin.

4485. **Correction of an electric bell.** George Michaelson, 33, Unter den Linden, Berlin.

4522. **Improvements in electrically-operated clocks.** Alfred Julius Boult, 323, High Holborn, London. (Henri Campiche, Switzerland.) (Complete specification.)

4539. **A joint for wires and electrical conductors.** Wilhelm Dieselhorst and Siemens Bros. and Co., Limited, 28, Southampton-buildings, Chancery-lane, London. (Complete specification.)

4540. **Improvements in contact bars for the overhead conductors of electrical railways and tramways.** Siemens Bros. and Co., Limited, 28, Southampton-buildings, Chancery-lane, London. (Messrs. Siemens and Halske, Germany.)

4554. **Improvement in telephony.** Charles Adams-Randall, 1, The Avenue, Bedford-park, London.

SPECIFICATIONS PUBLISHED.

1886.

8379. **Secondary batteries.** Reckenzaun. (Second edition.)

1889.

18755. **Plates for secondary batteries.** Reckenzaun. (Second edition.)

1890.

4699. **Telephony.** Kellogg. (Second edition.)

1893.

3477. **Galvanic elements.** Nehmer.

3573. **Extracting metals by electricity.** Taussig.

6470. **Electrical measuring instruments.** Mills. (Kennelly.)

7190. **Magnetic parts of electrical apparatus.** New.

8087. **Arc electric lamps.** Brockie.

24392. **Electric motors for vehicles.** Winkler.

24926. **Arranging wires for electric bell, etc., circuits.** Brierley. (Weber and another.)

1894.

135. **Transmitting electric currents.** Pupin.

495. **Transformers for electric currents.** Thompson. (Coffin.)

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	2⅜
— Pref.	—	2¼
Charing Cross and Strand	—	5
City of London	—	11⅛
— Pref.	—	13½
Electric Construction	—	1⅜
House-to-House	5	1½
India Rubber, Gutta Percha & Telegraph Co.	10	23½
Liverpool Electric Supply	5	6¼
	4½	5½
London Electric Supply	5	1
Metropolitan Electric Supply	—	8⅜
National Telephone	5	4¾
St. James', Pref.	—	8
Swan United	3½	3⅜
Westminster Electric	—	5½

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NOTES.

Traction at Bristol.—Plans are already being prepared for the electric tramway to Kingswood.

Prescott.—The lighting of the town by electricity is now considered by the Local Board to be satisfactory.

Church-Lighting.—The parish church of St. Mary, at Swansea, was lighted by electricity for the first time on Sunday.

Chemical Society.—The annual general meeting of this society will take place on the 22nd inst., commencing at 8 p.m.

Scarborough.—It is intended to light the Spa by electricity, and the current will be obtained from the electric lighting company.

Littlehampton.—Mr. W. E. Hayne, of Western-road, Brighton, has addressed to the Local Board a long letter referring to electric lighting.

Carriage-Lighting.—The Sherborne Electric Installation and Dorset Polytechnic Company, of Sherborne, are now equipping carriages with the electric light.

Dartford.—The Local Board have decided to renew the gas contract for one year only, and at the end of that period to consider the advisability of lighting the town by electricity.

Sydney.—The Military-road tramway, Sydney, having a length of 2 miles 11 chains of single track, is worked with the electric plant which was previously in use on the Randwick-Waverly line.

Book Received. — We have received from MM. Baudry et Compagnie, of 15, Rue des Saint-Pères, Paris, copy of "Traité de Télégraphie Electrique," by M. H. Thomas, telegraph engineer.

Tower-Lighting.—The Wainhouse ornamental tower in the Calder Valley, between Sowerby Bridge and Copley, is illuminated with arc lamps and a powerful search-light which can be seen for miles round.

Royal Institution.—An address on "The Scientific Work of Tyndall" will be delivered this (Friday) evening by the Right Hon. Lord Rayleigh before the Royal Institution of Great Britain, Albemarle-street, Piccadilly, W.

The Question of a Day Load.—An endeavour is being made to induce the Bristol Town Council to utilise their electric lighting plant for supplying current for motive power purposes during the daytime to various factories and workshops.

Madrid Universal Exhibition.—The Department of Science and Art has received, through the Foreign Office, a copy of a despatch from her Majesty's Minister in Madrid announcing that this exhibition will be opened at the end of May this year.

Wolverhampton. — The Board of Trade have approved the system proposed to be adopted for the supply of electrical energy within the borough, and the Local Government Board have formally sanctioned the borrowing of £30,000 for the purpose.

Cheap Motive Power.—The Bradford Town Council on Tuesday confirmed a recommendation of the Gas and Electricity Supply Committee that the price to be charged for current supplied for motive power purposes from April 1 next to October 1 next should be 3½d. per unit.

Mysore.—Direct Government telegraphic communication between Bangalore and Mysore is to be established. Messages from Bangalore to Mysore have hitherto had first to be wired to the head office in Madras and from there communicated to the capital through the Ootacamund office.

Norwegian Submarine Cable. — The Danish-Norwegian telegraph cable between Peterhead and Egersund, in Norway, having broken about 150 miles east of Peterhead, the telegraph company's steamer "H. C. Orsted," of Copenhagen, has now spliced the break.

Engineers and Shipbuilders.—The sixth general meeting of the North-East Coast Institution of Engineers and Shipbuilders will be held to-morrow (Saturday), the 17th inst., in the Athenæum, Church-street, West Hartlepool. A paper on "Oil-engines," by Mr. William Stafford, will be read.

New Borneo Cable.—The Eastern Extension Telegraph Company have agreed to connect Borneo with Labuan by a branch cable, and the directors of the British North Borneo Company have decided to connect the capital of their territory, Sandakan, by telegraph and road across country, a distance of over 200 miles.

Royal Society.—Papers on the following subjects were down for reading yesterday (Thursday) afternoon: By Mr. E. Matthey, "On the Liquidation of Silver-Copper Alloys"; and by Dr. Kerr, F.R.S., "Experiments on a Fundamental Question in Electro-Optics: Reduction of Relative Retardations to Absolute."

Bournemouth.—The Sanitary Committee of the Town Council have received a letter from Mr. J. A. Greenleaves with reference to a form of refuse destructor by the use of which the heat produced can be utilised in the generation of electricity. The committee have instructed the surveyor to visit Halifax to see one in use and to report to the Council.

Abergavenny.—The Gas Committee of the Abergavenny Improvement Commissioners have obtained tenders for a report by an electrical engineer as to the advisability and cost of an electric light station. A number of tenders, ranging from 20 guineas to 100 guineas, was received, and the committee have accepted that of Mr. Manville, at 35 guineas, to include expenses. Mr. Manville has promised his report at an early date.

Lectures.—Mr. H. Somerville, B.Sc., gave on Sunday afternoon at St. George's Hall, Langham-place, a history of the birth and progress of the dynamo. Mr. W. Habgood, managing director of the British Volta Electric Glow Lamp Company, recently delivered at Great Missenden a lecture on "How Electricity is Generated." On the 7th inst., Mr. W. Perren Maycock, M.I.E.E., gave a lecture on "Electricity" before the Whitgift Grammar School, Croydon.

Extension of Mains.—The London County Council have granted permission to the Westminster Electric Supply Corporation to lay mains in Gillingham-street on both sides, and across Vauxhall Bridge-road, and to the House-to-House Electric Supply Company to place mains on the west side of The Grove, between Redcliffe-square and Tregunter-road, in a part of Onslow-gardens, and on the east side of Ashburn-place. Both high and low tension mains are proposed to be used in the latter case.

Lighting of Workhouses.—The Newcastle Guardians have appointed a committee to consider the question of lighting the whole of the workhouse by electricity. Mr. Parsons was invited to visit the workhouse, and reported that there was sufficient motive power in the workhouse to light the premises, after the first cost of installation, at a third of the present cost of lighting. Calculations tend to show, it is said, that after two or three years the substitution of the electric light will effect a saving of £250 per annum.

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Lighting at Derby.—Mr. Frederick H. Tulloch conducted an enquiry on Tuesday on behalf of the Local Government Board with respect to an application from the Derby Corporation to borrow £5,000 for the purposes of electric lighting. The town clerk explained that the £5,000 required was in addition to the £30,000 already granted, and was required for new machinery and further mains. It was really for extending the lighting of the streets beyond the obligatory area of London-road and Station-street.

Electric Welding of Rails.—It is stated that about 10 per cent. of the electrically welded rails in Boston have broken in service. The experiment proved that a continuous rail, protected by the pavement, shows no ill effect from expansion; but whether the rails broke from contraction or from inherent weakness due to the welding, is yet to be determined. Hereafter the entire end surfaces, including the head, will be united, and care will be exercised not to injure the fibre of the metal or to restrain the expansion due to the heat.

A Question of Expenses.—At the monthly meeting of the Newport County Council on Tuesday, Mr. Wilkinson wished to know why the electric lighting sub-committee had spent £47. 15s. in going to Chelmsford, when Messrs. Crompton offered to invite them and pay the cost. Mr. Parnall, chairman of the committee, replied that the firm did not give the sub-committee an invitation, but that the sub-committee in all these visits concerning the electric light had kept themselves free from any such influence on the part of anybody.

Water Power for Electric Lighting.—The electric light and power station for the town of Chambéry, near Lyons, France, is remarkable for the height of the waterfalls used to drive the turbines. These falls are on the Isère, about 11 miles from Chambéry, and, according to *Engineering*, the total head is 2,010ft. They will furnish about 2,000 h.p. The turbines are to drive seven 120-kilowatt alternate-current dynamos, giving an E.M.F. of 5,000 volts. At the points of distribution the potential will be reduced to 110 volts by transformers.

The Institution.—Mr. Alex. Siemens, the president of the Institution of Electrical Engineers, is to be congratulated for deciding, as he did at the gathering last week, that it would be good policy for the Institution to adopt the practice of the Institution of Civil Engineers and bring the meetings to a close at half-past nine. This was done at the last assembly, and we think that the majority, if not all, of the members of the Institution will appreciate this arrangement, which, it will be remembered, used to obtain, but was allowed to fall into abeyance by the late president.

Electric Lighting in Stirling.—A special meeting of the Stirling Town Council was held on Monday to determine whether the Corporation should apply for a provisional order to supply the burgh with electric lighting. An influential deputation having been heard in favour of the Corporation proceeding with an application to the Board of Trade, Provost Kinross moved a resolution to that effect, which was seconded by Bailie Forrest. Bailie Lawson, seconded by Councillor Macewen, moved an amendment in the negative, and on a division the amendment was carried. This decision annuls a previous resolution of the Council to apply for a provisional order.

Attaching Telephone Wires to Roofs.—A case of considerable interest to telephone companies, and particularly to telephone subscribers, has just been decided in Manchester. The judge, Mr. H. G. Shee, Q.C., ruled that there was no trespass on the part of a contractor in attaching telephone wires to the roof of a building for the use of a tenant, although the tenant only occupied one room in any part of the building. Mr. Shee also decided that the tenant in giving an order for the wires to be attached was acting within his rights, as he was making a reasonable business use of the premises, which had been let to him for business purposes.

Communication with Lightships.—The work of laying the first permanent cable between the shore and a lightship in the Ramsgate district was commenced on Saturday between Kingsgate, near the North Foreland, and the lightship on the Kentish Knock Sand, situated at about 20 miles off the headland. The cable has been laid by the telegraph ship "Monarch," and the cable was connected with the telephone on the lightship on Wednesday. The shore-end connection is with the coastguard at Kingsgate. The next of this dangerous series of sands to be connected is the North Sands Head, one of the Goodwin, with lightships opposite Ramsgate.

Electricity in Copper Mines.—It is announced in Butte, Montana, that electricity is to be used extensively in connection with the development of the copper properties owned by W. A. Clark. The Rothschild brothers are said to have become interested with Mr. Clark, and to have despatched to the ground a representative of a large English electrical machinery works. The plans contemplate the purchase of five electric hoists, nine electric pumps, both for station and sinking purposes, and electric drills. Electric cars will convey the ore from the mines to the smelters, and the handling of the ores by elevators will also be accomplished by the use of electricity.

Search-Lights on Ship Canals.—In a recent issue reference was made to the introduction of search-lights for use on vessels passing along the Manchester Ship Canal. Messrs. Baxendale and Co., of Miller-street, Manchester, who supplied the plant, have received from Captain McLaren, of the steamship "Grampus," a letter concerning the results of the tests of the search-light plant on that vessel. The captain states that the experimental trial of the search-light on board the "Grampus" coming down the Manchester Ship Canal on the night of the 2nd inst. gave great satisfaction. He found it of great service in the navigation of the canal, the passage being performed in a little over five hours, and he recommends it for use on the canal at night.

Royal Meteorological Society. — An ordinary meeting of this society will be held at 25, Great George-street, Westminster, on Wednesday, the 21st inst., at 8 p.m. Papers on the following will be read: "Relation between the Mean Quarterly Temperature and the Death-Rate," by Mr. W. H. Dines, B.A., F.R.Met.Soc.; "Effect on the Readings of the Dry Bulb of the Close Proximity of the Reservoir of the Wet Bulb Thermometer," by Mr. F. Gaster, F.R.Met.Soc.; "Duration and Lateral Extent of Gusts of Wind, and the Measurement of their Intensity," by Mr. W. H. Dines, B.A., F.R.Met.Soc.; "On the Calculation of Photographic Cloud Measurements," by Dr. K. G. Olsson; and on "Sudden Changes of the Barometer in the Hebrides on February 23, 1894," by Mr. R. H. Scott, M.A., F.R.S.

Electric Tramway at Cork.—The Committee of the Privy Council have sanctioned a tramway scheme for the city of Cork. The proposed tramways will connect the new station of the Great Southern and Western Railway Company with the Cork and Muskerry Railway Company's station. The Great Southern and Western Railway Company would contribute £2,000 towards the capital of the Cork City Tramways Company, and the Cork Steamship

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Company would also contribute. It is proposed to work the tramways by electricity. The directors of the company include Mr. Payne-Sheares, chairman of the Cork and Bandon Railway Company; the High Sheriff of the city of Cork; and the President of the Chamber of Commerce, Cork. The Harbour Commissioners have consented to a line passing over Parnell Bridge.

Taunton.—The Electric Lighting Committee of the Town Council reported on Tuesday that the works in connection with the extensions were progressing favourably. The engine and boiler had been received and fixed, and would shortly be ready for use. Several fresh applications had been received for installations, and the necessary connections were being made to supply current from the low-tension main. The committee further reported that Mr. J. A. Robinson, of the Great Western Railway, was about to leave Taunton, and they asked the Council to vote to them a sum, not exceeding £5. 5s., to be expended by them in the purchase of a small present, in recognition of the valuable advice and assistance rendered by him in connection with the carrying on of the electric lighting works during a period of great difficulty and anxiety to the committee. This proposal was agreed to.

Early Notions.—In the beatification of Scriblerus, as described in Cambridge's poem, electric fires are referred to, as is M. Bose's treatise "De Electricitate Inflammante et Beatificante." The action of beatification of Scriblerus seems to have consisted in "charging" him by means of a static machine. It reads:

> And now the glass by streng attrition urg'd,
> First the foul atmosphere around him purg'd;
> Then at the hero's feet began to play
> A flame more brilliant than the solar ray—
> The golden beams ascending now embrac'd
> Th' illustrious sage, and circle round his waist;
> Now fixt, and by increas'd effluvia fed,
> Diffused a glory from his awful head.
> Thus as he darts around electric fire,
> To vocal hymns they tune the sounding lyre;
> His high achievements in their songs relate,
> And hail him monarch of the hermetic state.

Who was Bose, or Bossius, as Cambridge calls him?

Electric Lighting of School Board Offices.—An example of combined lighting and warming is afforded by a complete electrical plant which has recently been put down at the offices of the London School Board on the Victoria-embankment. The plant, which is arranged in the basement of the new buildings, consists of two Babcock-Wilcox water-tube boilers, designed to work at a pressure of 150lb. per square inch. These boilers supply steam to a pair of Parsons combined steam-turbines and dynamos, the turbines being of the radial-flow type, and each of the dynamos being capable of supplying 32,000 watts. Adjoining the engine-room is an accumulator-room, in which there is a battery of storage cells for the electric current. The current is supplied to 1,000 incandescent lamps which are distributed throughout the buildings. The heating of the building is effected by means of the exhaust steam from the engines.

Electric Traction at Dublin.—Mr. George White, chairman of the Imperial Tramways Company, mentioned at a meeting of the latter on Saturday, that the report touched upon the important subject of the introduction on the company's lines of electric traction. He said that they had a continuous line of eight miles of tramway running from Dublin through Blackrock and Kingstown to Dalkey, and that the installation of electric traction was looked forward to with pleasure by the authorities, who foresaw the advantages which must result to the district in thus securing what would practically be a line of railway with all the advantages of speed and easy locomotion, without the disadvantages of the noise and smoke attending the ordinary railway. The company were the first possessing absolute parliamentary authority to use the overhead system in Ireland, and they believed that the negotiations they were entering upon would be attended with benefit to the Dublin Southern District Tramways Company.

Milde Telephone Company.—The prospectus has been issued of the Mildé Telephones and Electric Supply Company, Limited. The capital is £20,000, in 15,000 7 per cent. cumulative preference shares and 5,000 deferred shares of £1 each. Subscriptions are now invited for the preference shares. The Company has been formed with the object of acquiring the sole rights granted to Mr. M. Kotyra by Messrs. Ch. Mildé, Fils, and Co., of Paris, to sell their telephones in Great Britain and Ireland and the English Colonies; to establish local, provincial, and private telephone exchanges, and to carry on other branches of electrical work. Mr. Kotyra has been manager for Messrs. Mildé's works in Paris for many years, and he has now taken up the sole agency in this country. These rights Mr. Kotyra proposes to sell to the Company for the 5,000 deferred shares, and he has entered into an agreement to remain general manager of the Company for a term of three years. The offices of the company are at 60, Watling-street, E.C.

Electricity in Mining.—At a meeting of the North Staffordshire Mining Institute at Stoke on Monday evening, Mr. J. Vaughan Hughes, Assoc.R.S.M., read some remarks on a paper previously read by Mr. R. H. Wynne on "The Application of Mechanical Arrangements in Underground Operations." Mr. Hughes showed several diagrams and tabulated statements setting forth results obtained by the use of compressed air, gas, steam, and electrical energy. Mr. Wynne criticised the remarks of Mr. Hughes, especially as to the use of gas underground, and said he was halting as to whether electricity or compressed air was the best to apply for some secondary kind of power. Electricity would be quite inapplicable for long distances underground. Mr. E. B. Wain maintained that in North Staffordshire mines, where there were such varying circumstances, horse power was the best for haulage. Mr. J. J. Prest agreed very much with Mr. Wain as to horse power, and said with regard to electricity he did not think it would come into general use in mines so much as compressed air.

Personal.—We tender our congratulations to Mr. T. Caink, assistant surveyor, who has been appointed engineer and surveyor to the Worcester Town Council. Mr. Caink is the patentee of an improved form of gravity battery in which broken carbon is substituted for the sand or sawdust previously adopted, by which the internal resistance of the cell is greatly diminished; the patent also covers a special syphon for removing and recharging the liquids. He is likewise the patentee of a method of simultaneous lighting and extinguishing street lamps by electricity, by which temporary increase in the pressure in the mains closes for a few seconds an electrical circuit at the same instant that it opens the gas-way to the burner. At a meeting of the Chemical Society on the 1st inst. a certificate was read in favour of Mr. James Swinburne. Mr. C. H. Wordingham, A.M.I.C.E., has accepted the position of chief engineer to the Manchester Corporation electric works, at the invitation of the Electric Lighting Committee. Mr. Wordingham superintended the carrying out of the several contracts for the establishment of the central stations at Manchester and Whitehaven on behalf of Dr. Hopkinson, and has been running the Manchester station during the last three months.

"The Universal (J. A. Berly's) Electrical Directory."—A copy of this directory for the current year has reached us from Messrs. Alabaster, Gatehouse, and Co., of

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22, Paternoster-row, E.C. The directory comprises the names of the members of the electrical and kindred fraternities throughout the world, and the amount of work entailed in its compilation will be readily understood when it is mentioned that the British sections contain about 16,386 names, the continental sections 13,880, the American sections 9,370, and the colonial sections 2,155 names, being a total of 41,791 entries, many of which appear more than once. There are, however, approximately 18,414 names of different individuals and firms contained in the book. For simplicity and facility of reference the directory is divided into the four groups mentioned—namely, British, Continental, American, and Colonial. These are again subdivided into alphabetical and classified sections. The new names incorporated in the present issue number several thousands, and the total pages added to the work is 104 as compared with that of 1893, making in all about 800 pages of directory matter. The directory is the largest and the oldest electrical directory in the world, and the price is 4s., as on previous occasions.

Willans and Robinson, Limited.—As will be seen from our advertisement columns, the business of Messrs. Willans and Robinson, Limited, which was converted into a private company in 1888, is now being transformed into a public limited company. The Company's business in the construction of steam-engines has been carried on with large success at Thames Ditton, Surrey, for 13 years, and the Willans engines are known throughout the whole world as being economical in working and having a high rate of efficiency. The capital of the Company is £300,000 divided into 30,000 6 per cent. cumulative preference shares of £5 each, and 30,000 ordinary shares of £5 each. The present issue for which subscriptions are invited comprises 8,037 preference and 8,038 ordinary shares. With regard to the remainder, 14,463 preference and 14,462 ordinary shares will be alloted in part payment of purchase-money, while 7,500 shares of each class are reserved for future issue. The large increase in the Company's business has necessitated considerable extensions in the works and plant, and the Company has therefore been reconstructed on a wider basis. The subscription lists will close on or before Wednesday next, the 21st inst., for London, and on Thursday for the country.

Reverberatory Furnace with Movable Electrodes.—In the *Compt. Rend.* M. Moissan describes a reverberatory furnace with movable electrodes. The furnace consists of a parallelopiped of Courson limestone, in which is cut a somewhat large cavity, also a parallelopiped in shape, which is lined with alternate plates of magnesia and carbon, about 10mm. thick, so arranged that magnesia is in contact with the limestone, whilst carbon forms the internal lining of the cavity. A lid, of alternate plates of magnesia and carbon, covers the cavity, and a block of Courson limestone is placed above this lid. The electrodes are movable, and pass through slots cut in opposite sides of the furnace. At right angles to the electrodes a carbon tube, 10mm. to 20mm. in diameter, passes through the furnace, and is so arranged as to be 10mm. below the arc and 10mm. above the bottom of the cavity. If necessary, the tube can be lined with magnesia. By inclining the tube at an angle of about 30deg., the furnace can be made to work continuously, the reducible material being introduced at the higher end, whilst the product of reduction is drawn off at the lower end. With a current of 600 amperes and 60 volts, two kilos of fused metallic chromium can be obtained in about an hour, the metal being received in a crucible made of chromic oxide. The metal is white, finely granular, and very hard, and takes a high polish. The magnesia is prepared by heating strongly the basic carbonate, digesting the product with ammonium carbonate solution, and again strongly heating. It is then moistened with water and compressed. With this furnace silicon carbide and vanadium carbide can be readily obtained by the direct combination of carbon vapour with the vapours of silicon and vanadium.

Low-Frequency Alternating Current.—Referring to the low-frequency alternate current—25 per second—adopted at Niagara Falls, Mr. William Stanly, jun., in a recent article in the *Electrical World*, shows that for the transmission of power the use of very low frequencies is not justified, and he intends to show why such a procedure is bad engineering from the transformer standpoint. To sum up the virtues of high-frequency motors, we have, according to the author's calculations, first, a greater torque at all times for the material employed, and consequently a greater output; second, a lower impedance armature and a lower inductance in the armature circuit, consequently for a given load a smaller armature current; third, a smaller armature reaction and "blowing out" effect produced by armature reaction. The experience at Pittsfield, where for 15 months two-phase motors whose magnetising currents are supplied from condensers have been in operation, is a sufficient proof of the practical operation of condensers. These motors are operating at 130 periods per second. They are connected to all classes of work, operating, as they do, a sawmill, a woollen factory, machine shops, a printing office, etc., and it has been found, by actual observations of the voltmeter in circuit on the consumers' premises, that the variation of potential due to changes of load and lag on the motors does not average 2 per cent. of the voltage applied. The regulation of these circuits is as perfect as if they were simply operating lamps alone.

The Proposed British Pacific Cable.—At the meeting of the Intercolonial Postal Conference on Thursday of last week, at Wellington, the debate was resumed on the motion submitted by Mr. J. G. Ward, the president, recommending the Governments of the various colonies to consider the desirability of entering into an agreement with the other countries concerned in the enterprise to guarantee the interest, at the rate of 4 per cent. per annum, on a capital of not more than £1,800,000, to any company undertaking to lay a Pacific cable, provided the tariff charge does not exceed 3s. per word for ordinary telegrams, 2s. per word for Government telegrams, and 1s. 6d. per word for Press telegrams to and from Great Britain and the colonies. The motion was discussed at great length and eventually adopted. Mr. A. Wynne, the Postmaster-General of Victoria, declared during the deliberations that his colony was satisfied with the present cable; but that, if the whole of the colonies and the Imperial Government agreed to pay their proportion of the guarantee, he would support the scheme. Mr. W. H. Wilson, Postmaster-General of Queensland, announced that he was in thorough accord with the motion, and that the Government of Queensland would do everything in its power to help the promoters to carry the project to a successful issue. Dr. J. A. Cockburn, the representative of South Australia, and the Postmaster-General of Western Australia, announced that they were unable to vote on the question. Mr. James Inglis, formerly Minister of Education of New South Wales, who is now in London, is keenly interested, as chairman of the Sydney Chamber of Commerce, in the proceedings of the Australasian Postal Conference. He stated that it was immaterial to New South Wales whether the cable started from Queensland or New Zealand; but the eastern colonies of Australia certainly felt that a second cable was needed. New South Wales had been committed to the New Caledonian project before

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Parliament was consulted, and she would not repudiate her obligations, although they involved an expenditure of something like £60,000. It was highly improbable that a Pacific cable which passed through the territory of a foreign Power would commend itself to the people of Australia or New Zealand. As approved by the Postal Conference, the cable would touch at no point outside British influence.

Lighting of the Victoria-Embankment.—It will be remembered, as stated in our last issue, that the London County Council postponed the consideration of a report by the Highways Committee concerning the electric lighting of the Victoria-embankment. As will be recollected, the Council on the 13th ult. referred back to the Highways Committee a recommendation which they then submitted regarding the laying of the conduits and the formation of refuges around the lamp columns in connection with the electric lighting of the Victoria-embankment, objection having been raised to the proposal to place the columns in the centre of the roadway. On Tuesday, the committee thought it well to give some of the reasons upon which they based their opinion that the best arrangement for lighting the embankment is for the lamps to be placed in the centre of the carriageway. They stated that: "If the electric lamps were to be placed along the kerb on each side of the carriageway it would be necessary either (*a*) to use very lofty columns for the lamps, or (*b*) to cut the trees in order to allow of the lamps being fixed in the desired positions. Should the former alternative be adopted, the trees would still veil the light from large portions of the road and footways, while the adoption of the second would involve a mutilation of the trees, which would greatly detract from the picturesque appearance of the embankment. In some of the continental cities the lamps are suspended by means of wires or cables; and this method necessitates the placing of standards in the carriageway to support the wires, except in the case of narrow streets where other means are adopted. Should these necessary supports be placed on the embankment against the kerbs, the span would be so great, on account of the width of the carriageway, that the lamps would be unsteady in the slightest breeze, and this would seriously diminish the effectiveness of the light. Owing to the width of the road it would be almost impossible, and certainly unadvisable, to erect arches or fix girders on standards for the purpose of carrying the lamps." Having again given careful consideration to the matter, the committee came to the conclusion that the least objectionable and the most advantageous method of distributing the light over the embankment would be by the erection of ornamental lamp columns, each with a small refuge round it, not exceeding 4ft. in width, in the centre of the carriageway. This is at no part less than 64ft. in width from kerb to kerb, and there would be left on each side of the refuges a space of 30ft. The committee saw no reason for altering the recommendation which was referred back to them on 13th ult., which they again submitted. The committee therefore recommended that, subject to an estimate being submitted to the Council by the Finance Committee, the work of laying the necessary conduits and the forming of the refuges round the lamp columns in connection with the electric light installation for the Victoria-embankment, etc., should be carried out by the Council without the intervention of a contractor; and that the plans, specification, and estimate should be referred to the Works Committee for that purpose. A long discussion ensued upon this proposal, and in the end the Council expressed the opinion that it was undesirable to erect lamp columns in the centre of the roadway.

Determination of Electrical Resistance by Alternating Currents.—In the "Foreign Abstracts" of the Institution of Electrical Engineers is given a summary of an article by Prof. F. Kohlrausch published on this subject in *Wiedemann's Annalen*. This article is an amplification of the author's former work on the subject, in which he communicates the results of his experiments on the conditions of accuracy and trustworthiness of the method which he has introduced. He is of opinion that the difficulties, uncertainties, and the small differences which sometimes occur in the determination of the resistance of electrolytes by means of alternating currents are due more to chemical than to electrical causes, and to the influence of temperature. The author's apparatus consisted of a Hartmann and Braun induction coil, with a platinum and quicksilver break under distilled water, working at about 85 interruptions per minute, and having 5 and 30 ohms resistance in the two coils; and the rest was as described in the former article. . The results were as follows: The accuracy of the placing of the bridge contact was 1 in 10,000 under favourable circumstances; and if the position of minimum sound is indefinite, owing to polarisation, self-induction, or capacity, the determination of the mid-point between two positions of similar amount of sound gives the resistance nearly correctly. Chaperon has introduced for telephone work a method of winding resistance coils up to 30,000 ohms; but for ordinary resistance coils it was found that up to 1,000 ohms they might be used with impunity, and up to 4,000 ohms the errors were $\frac{1}{3}$ per cent. and more. Wien states that the error varies as the square of the resistance and the capacity, and the coils for large resistances should be subdivided, rather than wound all on the one bobbin, as the capacity is thereby diminished; and the use of a condenser in shunt to large resistances is recommended. The preparation of sufficiently inductionless coils is not difficult. The error due to polarisation diminishes with the size of the electrode and the resistance: platinum electrodes of 10 and 35 square centimetres surface respectively in cells having resistance of 8 or 25 ohms, gave error of 3 or 1 per cent., and 1 and $\frac{1}{3}$ per cent. differences in telephone and induction coil seemed to have no observable effect. If the product of surface and resistance be 250 ohm-square centimetres or more, the error which may be anticipated will not exceed 1 per cent. In using platinised electrodes a good coat of dull platinum must be used. Sine currents are much more influenced by polarisation. When large resistances are to be measured, special precautions must be taken; as, for instance, inductive effects of coil on bridge and telephone, which must be avoided by suitable means. In the case of water and very dilute solutions the electrostatic capacity of the liquid cell, which is proportional to the specific inductive capacity and the specific resistance of the liquid, disturbs the minimum; but this effect is not serious, and should not introduce 1 per cent. error. When the resistances are of the order a hundred thousand ohms, the disturbances in the telephone due to static charges become annoying; but they can often be removed or mitigated by a suitable earth connection; but with resistances of the order megohms, the errors may amount to several per cent. Other small difficulties are due, in the water bath, to charges on the sides, and these increase as the size increases; they did not occur in a petroleum bath. A want of symmetry in the telephone sometimes occurs with large resistances, and is probably due to static charges. In such a case the telephone must be reversed and held in similar position, and the mean contact point used. This effect seemed to be greater with an induction coil having laminated core than with one having a metal tube over its core.

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PRIVATE ELECTRICAL ENTERPRISE IN CHELTENHAM.

The economical utilisation of spare power is a problem which always has a great fascination for mechanical engineers; but to the electrical engineer it is of far greater importance, as it may enable him to perform work which otherwise would be quite out of the question, owing to the initial cost of the requisite motive power. In very many manufactories in this country, such as breweries, etc., where an engine of considerable power is required for actuating grinding mills, pumping plant, hauling apparatus, and similar contrivances, it is absolutely essential that the power be such that it will be capable of doing the work at all times, even when the whole of these appliances are in use simultaneously. Considering the character of the operations in such an establishment it follows that during a day's work there must be intervals when there is a considerable amount of spare power available. It is a well-known fact that an engine gives a far greater efficiency when working at full load than when working with a light load, and it is therefore desirable to increase the load factor as much as possible so as to produce a maximum economy in working. By the employment of a system of electrical storage it is quite easy to convert an intermittent and irregularly generated current into one of perfect regularity. When utilising storage batteries it becomes possible to convert and store electrical energy produced intermittently during a day's working, and to use it at night as a constant supply for illumination and other purposes.

As an example of the successful utilisation of spare power, an installation in Cheltenham which has just been partly completed may be cited. The Cheltenham Original Brewery have placed in the hands of the Lithanode and General Electric Company, of London, the work of lighting their brewery works, the offices and manager's house, and the adjoining Fleece Hotel. Part of this work has now been completed, and on Thursday evening in last week the current was turned on in the Fleece Hotel, the manager's house, and the brewery offices. The work in question has turned out a thorough success, and those who were invited to see the light put on expressed great admiration at its steadiness and the effective way in which all the rooms in the hotel were illuminated.

The general manager of the Lithanode Company, Mr. J. T. Niblett, in conjunction with the proprietor of the hotel, Mr. Hart, made the opening ceremony the occasion for exhibiting a number of interesting appliances, all actuated by electricity. In one of the stock-rooms were shown electric cooking utensils, such as frying-pans, stew-pans, etc., also electrical devices for heating curling-irons, boiling shaving water, and working cigar-lighters and similar appliances. The reconversion of electrical energy into motive power was demonstrated by an electromotor, which was made to propel a ventilating fan, used to ventilate and perfume the room. Among other electrical contrivances shown were carriage and brougham lamps, 'bus and tramcar lighting apparatus, together with a good assortment of lithanode hand-lamps, miners' lamps, etc. Perhaps one of the most telling features of this little exhibition was some electrically-lighted artificial flowers, which attracted much attention and admiration, especially among the ladies.

The Fleece Hotel is the first hotel in Cheltenham to be lighted by electricity. The building is one of those old-fashioned posting-houses now fast disappearing, and consequently, although the house is exceedingly roomy and well-appointed, yet the ceilings in some of the apartments are somewhat low-pitched; and, consequently, when the gas was in use some inconvenience was occasionally experienced from the overheated condition of the apartments. On the substitution of the electric light a marked improvement was observable in the state of the atmosphere, not only in the commercial and other public rooms, but also in all parts of the house.

The proprietor of the hotel is not a man of half measures, and in addition to all the usual offices, billiard-room, smoke-room, writing-room, commercial and coffee rooms, and all the bedrooms, he has had all the corridors and passages and even the pantries and lavatories lighted up by electricity. The hotel contains, among its other accommodations, seven or eight very large stock-rooms; in fact, some of these are said to be the largest in the county. In the stock-rooms the introduction of the electric light has effected a very marked improvement, and the new light will doubtless be greatly appreciated by commercial gentlemen visiting this hotel.

As previously stated, only part of the installation is now finished, but when completed the installation will comprise between 500 and 600 lamps of varying candle-power. The storage batteries used in this installation are an important factor, and these will have a capacity of about 1,200 ampere-hours, and will be capable of running the whole of the lights in the installation for a period of 10 hours when once charged. The accumulators are of the lithanode type, and have been specially made by the Lithanode Company for this installation. The generating and storage plant is in duplicate, there being two dynamos and two sets of accumulators. By the utilisation of a variable resistance in the shunt circuit of the dynamos it is possible to run the lamps direct, either from one or both machines; and by a suitable alteration of the resistance the potential may be raised sufficiently high to charge the accumulators. Arrangements are also made on the switch-board for running one or both dynamos in parallel with one or both sets of accumulators if at any time it is found necessary to do so. The potential of the discharging circuit is 100 volts, and by the employment of two dynamos the generation of the electrical energy may be arranged to suit the load on the engine at any particular time of the day; and as the light may be obtained either from the accumulators separately or conjointly with the dynamos, it follows that the possibility of a complete breakdown is reduced to a minimum.

The engine used by the brewery is one of Savory's, and is of the horizontal type. It is a slow-speed engine of the type usually employed in breweries for pumping and hauling, and is nominally of 30 h.p. To increase the speed a countershaft is used, and this countershaft is propelled from a large driving pulley placed on the main shaft of the engine. The dynamos are of Messrs. Crompton and Co.'s make, and when revolving at their full speed—viz., 1,600 revolutions per minute—are each capable of developing 135 volts and 40 amperes.

The switchboard, placed in the engine house, which controls all sections of the installation, although it has to perform a number of functions, is exceedingly simple in construction. Two double-pole switches and fuses are placed on the board, and these are arranged so as to cut in or out the dynamo and battery circuits. Two of Lord Kelvin's ampere-gauges are used, one being placed in the charging and the other in the discharging circuit, so that both factors can be read off simultaneously. To prevent a back rush of current through the dynamos an automatic cut-out is of course used. One of Lord Kelvin's multicellular voltmeters is employed for indicating potentials; and by the use of an ingenious and simple switch the voltmeter can be used for testing the potential of the lighting circuit, the potential of the charging circuit, the charging circuit for either battery, the pressure of the batteries themselves, and also the electrical pressure being developed by each dynamo, or the pressure of the lamp circuit. Near the switchboard, and on a level with it, is placed a lever actuating a stepping-up switch placed in the battery-room, which is situated just above the dynamo-room. By this arrangement the engine-driver need not leave his engine-room when making any necessary change in the arrangements of the circuits, and he can also regulate the potential of his discharging circuit by throwing cells in or out. As a means of checking the consumption of electrical energy in the hotel, one of Lord Kelvin's latest type of electricity meter is used. This meter is placed in the cashier's office, which is centrally situated in the building. The supply mains run direct to the meter, and from there they rise to the top of the house, distributing-boards being employed for each floor. The electrical installation in question is being carried out by Mr. M. Sutherland, the Lithanode Company's electrical engineer.

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A similar installation, but of somewhat smaller dimensions, was carried out some time ago by the Lithanode and General Electric Company at the Gresley Brewery, near Burton-on-Trent. This somewhat novel installation has been in successful operation for a period of over six months, and was carried out by the Lithanode Company's representative, Mr. E. G. Fishenden. In this instance also, the spare power obtained from the pumping-engine is utilised to charge accumulators. As a result, the Gresley Brewery is now being effectively lighted throughout at a very nominal cost—the cost, in fact, only being the interest on the invested capital with the addition of a small sum per annum which must be allowed for depreciation.

NORTHERN SOCIETY OF ELECTRICAL ENGINEERS.

The second meeting of this society was held at Manchester last Monday, when the two papers given below were read and then discussed by Messrs. Wordingham, A. B. Mountain, W. Fox Bourne, J. Conolly, E. W. Cowan, L. Andrew, and R. Taylor—the discussion then being adjourned to the next meeting, to be held on Monday, April 9, though previous to that a smoking concert, the second of the series, is to be held on Monday, April 2.

At the meeting the following new members were elected: Geo. Broughall, Manchester Edison-Swan Company; T. B. C. Nuttall, Siemens Bros., London; A. Oughterson, Messrs. W. T. Glover and Co., Manchester; F. A. Pocklington, Callender Bitumen Company, Liverpool; R. P. Wilson, Wilson and Clirehugh, London.

Notes on Designing a System of Underground Electric Light Mains.

BY JOHN H. RIDER.

The importance of a satisfactory system of underground mains in a scheme for town-lighting may be estimated when we consider that in generating the electricity we have only done half the work. We have still to convey it to the consumers, and in many cases this means to distribute it over a wide area. The difficulties met with in so doing have given rise to the various systems of "high and low tension," and of "continuous and alternating currents," which have been so much discussed by electrical engineers. It is not my intention, however, to dwell on these points, but rather to offer some observations on underground mains generally.

At whatever pressure we may generate our electricity, we are compelled by law to deliver it to our customers at a low pressure. In the case of a general low-pressure system, this is done by means of a distributing network, fed at various points by feeder cables. When the generation is at high pressure, we may use either a low-pressure distributing network, fed through transformers at various points, or we may place transformers on the consumers' premises, and so have practically no low-pressure network at all. The Board of Trade, however, will now only give its sanction for this latter course on the distinct understanding that, when called upon to do so by them, a low-pressure distributing main will be laid down and the house transformers removed. Therefore all arrangements using house transformers can only be looked upon as of a temporary nature.

At the outset we should make a radical distinction between "distributing mains" and "feeders."

"Distributing mains" are those from which the services to the houses are taken. It is therefore necessary to have them of such a cross-section that the fall in pressure from any feeding point to the farthest service on that section does not exceed, say, 2 per cent. when all the lamps are burning. Then, if we keep the various feeding points at a uniform pressure, we may be certain that the whole of the distributing network has a voltage within 2 per cent. of this. In the case of an ordinary business street, it will be found necessary to have the feeding points at not greater than about 250 yards apart, in order to have the distributing mains of a reasonable size.

"Feeders" are mains going direct from the station to the various feeding points, and their use is to feed the distributing network through transformers or otherwise. While we may take more than one feeder to any feeding centre, yet in no case should we arrange any one feeder to supply more than one feeding centre. We should find it impossible to keep the voltage constant all over our distributing network, if we did so. The pressure at the feeding centres must be kept constant by raising the pressure of the several feeders at the station, in proportion to the current flowing through them. As it is impossible to say that the demand for current will always be equal all over the network, it will be necessary to regulate each feeder independently of the others. On direct-current systems this means raising the pressure of the dynamos when the load comes on, and, when the feeders are supplied from omnibus bars, having a regulating resistance in each feeder.

On alternating-current systems the pressure of the machines need not be altered, as the necessary voltage may be added to the feeders by means of adjustable transformers in series with them. The most satisfactory method of indicating at the station the voltage at the different feeding centres is to run back pilot wires from each, and to connect them to voltmeters on the switchboard. The attendant has then simply to regulate for constant volts, and the current in each feeder will take care of itself. In all cases the pilot wires should be connected to the low-pressure network, and not to the high-pressure side of the transformers, as has been done in some alternating-current stations. As the feeders in many cases will be long, we must allow a much greater fall of pressure in them at full load than in the distributing mains. It no longer becomes necessary to keep an approximately even pressure over their whole length, as we do not take service wires from them. In many low-pressure systems a drop of from 10 to 20 per cent. at full load is allowed, and this of course has to be met at the station by an equal increase in order to keep the pressure constant at the feeding centres. If we use larger feeders we shall have less drop, and if smaller then greater drop.

Lord Kelvin's rule is generally quoted in this case—viz., that the maximum economy is obtained when the annual interest on the cost of the feeders equals the annual cost of the energy wasted in them. But it must not be forgotten that small feeders and a large loss also mean larger plant, in consequence of the increased pressure required. This will go to make the cost of the wasted energy higher.

We may divide the many systems of laying mains into two chief classes, "drawn in" and "built in." By the former I mean those which are drawn into pipes or conduits, and by the latter those which are either laid direct in the ground, such as armoured cables, or run in solid with bitumen, etc., such as Callender's solid system. Each class has its advantages and disadvantages, which are, however, much modified when applied to both feeders and distributing mains.

The chief advantages of a "drawn in" system are: (1) easy to inspect, (2) easy to add cables, (3) easy to withdraw cables. As a "drawn in" system generally requires more inspection than a "built in" one, it provides its own remedy. In order that cables may be easily added, it is essential that the conduit should be made large enough, or that spare pipes should be provided. This tends to increase the prime cost. When a "drawn in" system is used for the distributing mains, and service branches are taken off, it becomes impossible to remove the cables without first disconnecting all the consumers. For feeders, however, as no branches are taken off, this is no drawback.

The "built in" systems have the advantages of: (1) generally requiring less space, (2) being easier to lay, (3) no danger from gas or water, (4) less prime cost. Their chief disadvantage lies in our being unable to increase them without reopening the streets.

For low-pressure distributing mains, this disadvantage need not be one at all; for if these mains be calculated with reasonable care for the requirements of the district, they should rarely require enlarging. And if at some future time a greater demand comes at one point than the cables can carry, the simplest way is to run another feeder to that point, and to leave the low-pressure network as it

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was. This, of course, means that the feeders should be laid on a "drawn in" system.

I venture to think that a combined system of "drawn in" for the feeders, and "built in" for the distributing mains, offers a number of advantages. The distributing mains should only require extending in order to light new streets, and opening the ground may be therefore allowed. But new feeders have in many cases to be taken through streets already lighted in order to reach the new districts, and so they should be "drawn in" to avoid opening the same streets a second time. Opening the streets is such a nuisance to everybody, besides being very expensive, that this point is well worth consideration. Judging from recent experiences, a considerable difficulty in connection with a "drawn in" system, is the danger from gas explosions. There can be little doubt that the gas comes from leaky or broken gas-pipes in the vicinity of the conduit. It is useless to look to the gas companies to lay their mains so that leakage would become impossible. An unlooked-for subsidence of the soil may cause a drawn joint or broken pipe, and it then only requires a spark to complete the mischief. A thorough ventilation of all electric pipes, conduits, and manholes, together with great care in the laying and subsequent inspection, seems the only way to minimise the risks. The perfect freedom of an armoured cable system laid direct in the ground from such accidents is without doubt a very strong point in their favour. In most "drawn in" and in some "built in" systems it is necessary to either make service-boxes opposite the houses as the cables are laid, or else to build such boxes with iron pavement covers when required. Both are expensive methods. But with an armoured cable we need make no preparation for future service connections. Each case is dealt with as it arises, and by the use of a small split junction-box of cast iron placed around the cable, and afterwards filled up with insulating materials, the joints can be well and cheaply made.

So far what has been said will apply with equal force to either continuous or alternating current systems. But alternating-current mains require special precaution to be taken in their design, which need not be considered at all in the case of those for continuous currents. Any current of an alternating or varying character flowing in any conductor will set up E.M.F.'s in neighbouring conductors, and as a result of these E.M.F.'s currents will flow depending in strength upon the resistances encountered. It is most essential that adjacent wires should be protected from such currents, and the remedy that suggests itself is to entirely surround the alternating-current conductors by a metallic sheathing, such as an iron or a lead covering. This, however, would only remove the disturbances from the neighbouring wires to the sheathing itself. It would not prevent them altogether, but may, in fact, increase them, and so cause a great waste of energy. To stop them, it would become necessary to place both the flow and return conductors within the same pipe or sheathing, and if the system were a three-wire one, then all three wires must be so treated. A perfect cure is only obtained when the conductors are so placed with respect to the pipe or sheathing that their centres are practically coincident. A concentric cable meets this condition, either when drawn into an iron pipe, or when lead-covered and armoured. I believe many alternating-current systems are working where this precaution is more or less disregarded, and the amount of power lost through waste currents is unknown. Considering that these losses are going on all the time the station is running, they must amount to a good deal in the course of a year, and in some cases may probably equal the magnetising current losses of the transformers. It would appear that this question is either not understood or else ignored by many who have to design alternating-current mains. In a recent case it was specified by a well-known engineer, that three separate lead-covered cables were to be used for a three-wire alternating system. In the scheme which I am at present carrying out, the actual arrangement for the low-tension mains was left open, so that every contractor might tender on his own lines and for his own system. It was distinctly pointed out that alternating currents were to be used on the three-wire system, and yet out of 20 different offers no less than nine had entirely overlooked the question of induced currents. Some firms proposed to use separate lead-covered cables, drawn into cast-iron pipes. Others offered separate lead-covered and armoured cables, to be laid direct in the ground. Others, again, proposed to use two concentric armoured cables, the middle wire of the system being divided and placed half in each cable. Of course, when the loads on the two sides of the system were such that no current flowed in the middle wire, each cable would act just as a single sheathed cable. These proposals came from firms of the highest standing in the cable trade, and would show that there are many persons who have not yet fully grasped the importance of preventing waste currents. As I said before, the three conductors must be under exactly the same conditions, and within the same pipe or sheathing, to entirely do away with the difficulty, and a triple concentric armoured cable meets the case perfectly. But when a triple concentric cable is used as a distributing main, the question of service joints comes in, and it is not the easiest matter in the world to make a good branch joint on such a cable. Not only are the branches to be pieced in, but the cable itself must be left continuous. The low-tension cable we have adopted in Bolton is made by Messrs. Siemens Bros. and Co., Limited, and consists of three separately insulated conductors twisted up together into one cable, and then lead sheathed and iron armoured. The effect of the twisting is to make the three conductors have practically the same centre. The making of service joints is much simpler than with a triple concentric cable, as when the sheathings are cut through, each conductor becomes accessible, and can be treated as desired.

With reference to a three-wire system, it is often stated that when the load is equal on each side, no current flows in the middle wire But although this is often true, it is not necessarily so, as it altogether depends where on the particular main the lamps are taken off. Suppose we have a three-wire main going out from a station or supply centre, and that close to the station 100 lamps are taken off on one side. At 150 yards away let another 100 lamps be taken off, but from the other side. Then our meters in the station would show equal current in the two outer mains, and we might assume that none was flowing in the middle wire. But for 150 yards of its length it would be carrying a current equal to either of the outer cables. This of course is an exaggerated case, but it will show that it depends upon the positions, as well as upon the numbers of the lamps, how much current flows in the middle conductor.

A point of great interest in connection with an alternating-current scheme is, that although the low-pressure distributing network may be laid on the three-wire system, yet it is only necessary to have two-wire feeders. The transformers must be made with three terminals on the secondary coils, and the primary current will then adjust itself to the mean of the loads on the two sides of the secondary. If the transformers be designed so that there is only a 2 per cent. total variation in pressure from no load to full load, then the difference in voltage on the two sides of the system can never be more than 1 per cent. even in the almost impossible event of full load being on one side and none on the other. In such a case the primary would take a current equal to half full load. This is of great practical importance, as the station machinery and switchboards can be arranged for a simple two-wire system, while all the advantages of a three-wire distribution are retained.

At all the principal points of interconnection in the distributing network junction-boxes should be placed, so arranged that the various sections may be easily connected or disconnected for the purposes of testing, repairs, etc. Soldered joints would be here out of the question, so the cable ends should be sweated into thimbles, which may be clamped together, or to properly-arranged connecting bars, as desired. If the insulating material be other than rubber, then the boxes may be filled up with oil to keep out the damp. The oil could be pumped out in a few minutes when it was necessary to make a disconnection.

A very important point in connection with an underground system of mains is the question of insulation resistance. I am inclined to think that a great deal too

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much is often made of shop tests on the cable, and far too little of tests when the cables are laid and all joints made. We may think because the cables give an insulation resistance of so many thousand megohms per mile after 24 hours immersion in water, that we are certain of an excellent system. Such tests and results are most excellent in their way, but what insulation resistance is obtained when the cables are laid? A badly insulated joint has a wonderful effect in producing bad results, and is practically equal to a faulty place in the cable. Therefore all joints should be most carefully watched while making, and a guarantee obtained from the contractor, rather of an insulation resistance when the cables are laid complete, than when individual coils are tested in a tank of water. Besides testing for insulation in the ordinary way, all cables should be tested for breaking down with a voltage at least twice the ordinary working pressure.

Conductors of bare copper should only be used for continuous currents of low tension, as if used for alternating currents it is practically impossible to lay them so as to avoid induction effects. They have been used by Crompton for continuous currents up to about 200 volts with considerable success, but on his system the conductors are tightly strained, and are supported on properly shaped insulators. In some cases bare strip has been laid in culverts, and carried upon porcelain bridge-pieces, which can only by courtesy be called insulators. Little or no attempt appears to have been made to prevent surface leakage on the supports, with the result that the insulation resistance of such mains is often a minus quantity. The liability of all such systems to stoppage from water flooding and the large sizes of the conduits required, are points against their use. Their only recommendation appears to be in the question of prime cost. A properly constructed and properly ventilated subway system under our streets would much simplify the question of laying electric mains. But the dangers arising from gas and water pipes bursting, to say nothing of the enormous cost, stand in the way of its adoption.

I trust these remarks may be of interest to the members of this society.

Various Systems of Underground Mains and Methods of Laying Same.

BY S. V. CLIREHUGH, A.M.I.C.E.

I feel that the subject of this paper needs no apology, as until quite recently the means by which electricity was to be conveyed to the consumer had not presented itself as one of the burning questions in the equipment of a central station. We have discussed in the technical papers and before scientific societies the question as to whether dynamos should be direct coupled or rope-driven. Columns have been written on the advantages or disadvantages of water-tube boilers as against Lancashire boilers, and vertical engines have been pitted against horizontal engines, but, as a rule, the question of the best system of mains has been left severely alone. Now, I am sure that any central-station engineer will bear me out in saying that the mains are one of the most important points of a central station, and on them depends to a very large extent the satisfactory working of the station. Everything else from boilers to dynamos is duplicated, but mains it is practically impossible to duplicate. There is no stand-by, hence the importance of selecting a system with the utmost care.

Let us consider what are the first things to be aimed at in any system of mains.

1. *Cheapness.*—This is always an important point to consider, as it is generally the non-technical public who find the money, and it is difficult to convince them that very often cheapness in this particular line is very false economy.

2. *Long Life.*—Very little actual experience is available as to the probable duration of any form of insulating material at present in use.

3. Facility for increasing the sectional area of copper without disturbing the surface of the ground.

4. Facility for fault-finding, repairing, inspection, jointing, etc.

Having detailed the various points which are considered desirable in a system of underground mains, we may now consider to what extent we can combine them in any one system, and what are the various materials at our disposal.

There are, broadly speaking, three systems to be considered: (1) insulated cables in conduits, (2) armoured cables, (3) bare copper in culverts. One of the oldest systems which was practised on anything like a large scale was that of laying cast-iron pipes 3in. to 4in. in diameter, into which were drawn insulated cables, boxes being built at first about every 80 yards merely for the purpose of drawing in the cables and making straight joints. This plan is in my opinion very suitable for a district in which it is difficult to ascertain the probable demand which is served with a high-tension alternating-current system—the *modus operandi* being as follows: a cable having a conductor of small sectional area, say, $^{7}/_{16}$S.W.G., is drawn into the pipe and the first consumers are supplied therefrom, transformers being fixed on each consumer's premises. When the demand becomes sufficiently great—that is to say when there are, say, 12 consumers within 100 yards—the high-tension services are then cut off in the boxes which are built as occasion arises. A transformer station is then built, and a low-tension main is drawn into the pipe. The high-tension feeder being left in is available for feeding this and more distant points. If it is likely to be necessary to draw in many separate cables, it is advisable to lay two pipes, as several cables laying in one pipe have a curious way of twisting themselves together, thus rendering it difficult to pull out any particular cable.

We now come to the question of the insulating material, which we are going to draw into the pipes. Insulated cables may at once be divided into two classes. One in which the dielectric is unaffected by the presence of moisture, the other in which the dielectric must be protected from moisture of all kinds by being hermetically sealed in a metallic envelope. The materials used to insulate the first class of cables are indiarubber, guttapercha, and bittite, and for cables of the second class, jute, hemp, cotton, and paper impregnated with oil, wax, or bituminous or resinous compounds. We will now consider cables of the first class. In connection with these the only insulating materials, as far as the author is aware, worthy of consideration are indiarubber and bittite—okonite, as far as the author knows, never having been made commercially in this country. Guttapercha, although probably the first insulating material used, is now used solely for telegraph and telephone purposes, and that now to a limited extent except in the case of submarine cables, where it still holds its own. The great objection to the use of guttapercha, except for submarine telegraph work, is that it softens at a very low temperature, and when exposed to the light and air becomes brittle and cracks, sometimes even crumbling away into powder. Cables insulated with vulcanised indiarubber stand no doubt from a scientific point of view at the top. We have now had considerable experience in the question of the life of indiarubber as an insulator I hardly know how many years, but I am sure Mr. Preece will be able to give us further data. I myself remember taking out some indiarubber cables which were laid in London for the London Electric Supply Corporation, and which had been in constant service many years, which showed not the slightest signs of deterioration, and I may mention that the only reason they were removed was to enable them to be made concentric; they were replaced, and are working to this day.

I should like to say a few words on the question of vulcanising indiarubber. As you are all probably aware, vulcanising has only been known about 30 years. I again must appeal to Mr. Preece. Prior to that time cables were insulated with pure rubber strip lapped spirally round the conductor, the overlapping parts of the strip being made to stick together by the use of naphtha, which is a solvent of indiarubber. This, of course, was most unsatisfactory, and caused the rubber to decompose very rapidly. I often wonder what will become of the mass of joints in house wiring in 20 years' time. Vulcanising, of course, went through various stages, with which I need not trouble you, before it reached its present one. The process is in itself very simple, but requires long practice and considerable skill before it can be satisfactorily carried out. It is as follows. A small quantity of sulphur is mixed with the rubber, [and the mixture is subjected to a

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temperature of about 250deg. to 300deg. F., whilst keeping it under pressure. The difficulties presented by the process are the different times required by the different classes of rubber, varying from one to four hours, for the cure and the amount of sulphur to be used. By vulcanisation the sulphur combines chemically with the rubber, with the result that the decomposing agent is neutralised. In some places the difficulty offered by being unable to keep a vulcaniser is serious, as the men are highly paid, and on a small station there is not, of course, sufficient to keep even one fully occupied. In such cases it is sometimes necessary to use mechanical jointers—*i.e.*, cast-iron boxes which are placed over the joint, bolted together, and filled with a bituminous compound. This makes a thoroughly good job, but it is very difficult to break the joint should it for any reason become necessary. Another plan is to insulate the joints with pure rubber strip, and when there are sufficient number of them, say 20 to 30, ready to be cured, get the cable manufacturer to send a vulcaniser down for a week or so. Vulcanising, it will be seen, is a very delicate operation, the success of the joint being entirely dependent on the care taken by the jointer, and too much importance cannot be laid on the point of cleanliness. A rough test as to whether a joint is properly cured is to try and mark the rubber when cool with the thumb-nail; if it is just right it will yield to the thumb-nail, but leave no mark; if it leaves a mark it is under-cured, and if it feels hard it is probably over-cured. The only objections, therefore, to the use of cables insulated with indiarubber are practically its high price and the difficulties in jointing. I would specially warn engineers to be very chary of purchasing low-priced rubber cables, as it is almost impossible for anybody not an expert to tell whether the rubber is good or bad quality. Low prices in rubber cables generally means that a large amount of compound has taken the place of rubber.

We now come to the only other practical insulating material—viz., bittite—of which I regret to say I have had very little experience. Bittite, which is the material used by the Callender Company, is believed to be bitumen refined to purity and vulcanised. The conductor is covered with a solid sheath of this material put on in one operation under pressure, and is served with a tape and covered with an insulating compound and again taped, then braided with a hemp yarn and passed through a bath of hot asphalte compound. Joints in the cables are insulated by wrapping the conductor with bittite, which has been half vulcanised, up to the diameter of the original insulation, and then protecting it by a wrapping of compounded tapes. The joint is then heated by means of a lamp to make the wrappings solid and to complete vulcanisation. This system of jointing is very simple, and no particular training is required for the purpose. The Callender Company had at one time, I believe, difficulties which they have now got over, owing to the tendency of the conductor to decentralise, and I have also heard that the insulation sometimes stuck to the culvert, rendering it difficult to remove. However, my experience with them is not of recent date, and as I see a representative of the Callender Company here he will no doubt be able to correct any errors into which I have fallen. Callender's cables are used very largely, and I believe with great success, in this country for low tension, but up to the present not much for high tension.

You will see on the wall a table giving approximately the cost of a yard of main on the three-wire system, low tension, of the various classes of cables, etc., and also for concentric cables for high-tension systems; the item for excavating and making good of course varies enormously, both according to the town and the nature of the ground.

We now turn to cables of the second class—*i.e.*, the insulation of which is not in itself damp resisting, but which has to be protected by a metallic envelope, and on this I feel some difficulty in expressing myself lest I should appear prejudiced, as I was for two years engineer to the British Insulated Wire Company, whose speciality is fibrous insulation applied in the form of a paper. In describing one lead-covered fibrous cable you have described them all, as they all have the same faults and the same advantages apart from the question of excellence of manufacture, into

Approximate Cost of Laying a Yard of Main on the Three-Wire System—The outer conductors having a sectional area of four square inches, the middle conductor two square inches.

System.	Cost of conduit.	Cost of conductors.	Excavating and making good, including laying and jointing conduit.	Total.
		£ s. d.		£ s. d.
4 sq. in. C.I. pipes, with indiarubber insulated cables drawn in.	2s. 0d.	1 3 0	5s., including boxes at the rate of 12 per mile.	1 10 0
4in. C.I. pipes, with fibrous lead-covered cables.	2s. 0d.	0 18 0	5s., including boxes at the rate of 12 per mile.	1 5 0
Bare copper strip.	Cost of culvert complete, including and making good, 17s.	1 10 0	Nil.	1 7

Callender bitumen three-way casing may be used at about the same cost as cast-iron pipes.

Cost of Laying a Concentric Cable suitable for a Pressure of 2,000 Volts—Each conductor having a sectional area of 155 square inches.

—	Pipe.	Conductor.	Excavations.	Total.
3in. cast-iron pipe, into which indiarubber insulated cables are drawn ..	1s. 8d.	11s. 6d.	5s. 0d.	18s. 2d.
Ditto, ditto, lead-covered cable	1s. 8d.	8s. 0d.	5s. 0d.	14s. 8d.
Armoured ditto	Nil.	9s. 0d.	4s. 9d.	13s. 9d.

which it would be invidious to enter. I have said above that indiarubber as an insulator stands scientifically at the top, which is no doubt true, but it is expensive, and if you can get an article which will answer the purpose equally well at a lower price it is certainly advisable to use it. The question now presents itself as to whether a fibrous cable will answer equally well, and I say decidedly, yes, if you are prepared to treat it with sufficient care. Very frequently, however, fibrous cables get into the hands of jointers who have been given no special instructions, and they treat it as they have been accustomed to treat a cable insulated with indiarubber, with, of course, unsuccessful results. Fibrous cables are not so flexible as those insulated with indiarubber, but for nearly all practical purposes are quite flexible enough. The manufacture of lead-covered fibrous cables is fairly well known. I will not detain you long in describing it, merely saying that the fibrous material, be it in the form of yarn or paper, is laid spirally round the cable, pressure being applied to solidify the mass as much as possible to the required thickness; the cable is then thoroughly dried out at a temperature of about 250deg. F. for 30 or 40 hours to expel every possible trace of moisture, and it is then immersed in wax, resinous oils, or similar materials at a high temperature. From this tank, without any further contact with the air, it is passed through a lead-press and so hermetically sealed. The great danger in these cables to guard against is the possibility of the formation of "pinholes" during the process of lead covering. These are produced by a variety of causes, but probably the most troublesome one is produced by impurities in the lead. These "pinholes" are very difficult to perceive during manufacture, but they are generally found by testing after prolonged immersion under water. It is very important in buying this class of cable to find out what insulation resistance the manufacturer recommends and to see that all cables of the same class have approximately the same insulation resistance after one minute's electrification and 24 hours' immersion in water. The electrification being very marked in this form of cable, it is essential to see that this limit is adhered to. One word about the insulation resistance of these cables. I have found by experience that it is better not to insist upon too high an insulation resistance, but to insist on its being uniform. Cable manufacturers are a good deal

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bothered by having high insulation resistance specified. It can be produced if desired, but, I believe, at the expense of the life of the cable caused by excessive drying out. The pressure test is a very useful one, and cables of this class should certainly be tested after immersion with at least double the pressure at which they are intended to work. The cables should again be tested for insulation resistance, and the result should be the same as before the pressure was applied.

We now come to the treatment of the cables after they are delivered in the streets, and we will assume they are to be drawn into cast-iron pipes. Cables which are to be thus treated should be either taped or braided outside the lead, preferably the latter, to prevent any roughness in the pipe scoring the cable. If the cable is a heavy one, some lubrication is often desirable, and for this purpose there is nothing better than soft soap. In a straight run with a moderate-sized cable, 80 to 100 yards may be drawn in in one length, great care being taken to avoid kinks or sharp bends. It will be noticed that the end of the cable is sealed up, and when this end is cut it must be resealed as soon as possible, as the insulation being very hygroscopic, the insulation resistance of the cable is quickly lowered if the end remain exposed too long to the atmosphere. A good temporary way of sealing the end of a cable is to lap it with dry cotton tape and plunge it into hot pitch. As regards jointing of these cables, you will see on the table samples of joints in various stages of manufacture which will illustrate the subject better than anything I can say. The only skilled labour necessary in making these joints is for wiping the joints, and an ordinary plumber will in the course of a few hours be thoroughly competent. Two holes are left in the lead sleeve, on to one of which a tube of about 12in. long is soldered and resinous oil is poured down the tube, the length of the column of oil causing sufficient pressure to enable the oil to thoroughly permeate the insulation of the joint. A straight joint in a concentric cable, say, $^{7}/_{16}$ S.W.G., should be completed in about one hour. When it is required to end a cable for any purpose a lead cup is soldered round the sheathing and filled with paraffin wax. The difficulties in connection with this class of cable are thus, it will be seen, largely overrated, and with due care it will serve every purpose that is served by rubber-insulated cables, the jointing being to my mind considerably easier. As regards the life of these cables, we are again without any actual experience to guide us, but I see no reason as long as the lead covering remains intact that any depreciation should take place. Through the courtesy of the Fowler-Waring Company and the British Insulated Wire Company, I am able to show you various samples of their manufacture. I think that, other things being equal, the paper insulation has an advantage from the fact of its cleanliness in jointing. The power of paper as a dielectric for resisting disruptive discharges is very high, and $\frac{1}{4}$in. radial thickness of insulation has been found sufficient to withstand a pressure of 20,000 volts, which, I believe, no other dielectric of this class would stand. No paper on this subject could pass without a word of reference to the mains invented by Mr. Ferranti. When Deptford was started and the idea of transmitting energy at a pressure of 10,000 volts was seriously entertained, no cable could be found which was likely to be able to withstand what was then considered an almost impossible pressure. Mr. Ferranti therefore invented his well-known main, a sample of which may be seen on the table, and it is noteworthy that after trying every conceivable form of dielectric he at last decided on paper as being most calculated to withstand the disruptive discharge. The first of these mains was laid when I was with the London Electric Supply Corporation some six years ago, and with the exception of damage caused by external injury they have been running very satisfactorily ever since. As these mains have now been quite superseded by the British Insulated Wire Company's manufacture which remove the principal difficulties in connection with their use, I need not trouble you with a description of their manufacture, which will be found in most text-books.

We have still one more cable under this class to discuss—viz., the Brooks oil insulation system. This system resembles the lead-covered fibrous cable system, as will be seen. The cables are sent out heavily braided, as will be seen from the samples; this braiding simply serves to keep the conductor from mechanical contact with the pipe. The iron pipes in which the jute-covered conductor and oil are contained are laid underground, and at the highest point in the pipe line a cast-iron tank is fixed, which serves as an oil reservoir and ensures the pipes being kept full of oil. The inlet to the boxes through which the cables pass are provided with glands, which thus allows the box to be emptied for testing purposes and making fresh connections. Those who have had anything to do with the heavy resinous oil used on this system will appreciate the difficulty of getting the oil out of the box and the horrible state of mess the jointer would be in. When the pipes and boxes have been laid and all joints made tight, the cables are drawn in. To prepare them for this stage, the braided cables are placed in a portable tank containing fluid insulating material, at a temperature of about 300deg. F., for a sufficient length of time to expel all moisture from the fibrous covering. They are then drawn into the iron pipes and oil is forced in to fill up all the spaces. This system might be suitable for feeders, but I should think it difficult to work on a system of distributing mains. I have, unfortunately, no figures as to the cost of this system. I have so far endeavoured to describe to you the various classes of cable which are suitable to be drawn into conduits and to point out the relative advantages and disadvantages of each, from which you will see that no hard or fast rule can be laid down, but each case must be governed a great deal by local circumstances.

Armoured cables may be dismissed very briefly—the principal object in their use is their supposed cheapness, which, however, is over-rated as will be seen from the table. They may be of service in outlying districts, and possibly in some cases for feeders, but there are many drawbacks to their use, one of the principal ones being the difficulty of fault-finding, as in any draw-in system whenever the fault is arrived at within, say, 20 yards, that length of cable can be drawn out and examined at leisure, whereas with an armoured cable you have to open many yards of ground before you actually arrive at it.

We now come to the last class of mains—namely, bare copper in conduits. Messrs. Crompton and Co. are the great exponents of this system, and you will see numerous samples indicating their system on the table. Much might be written on this class of mains, but as this paper is already of considerable length, it will suffice to describe one system—viz., the Crompton, as showing the principle—the other systems merely vary slightly in detail. The bare-wire system, it need hardly be said, is suitable only for low tension. The culvert consists of a concrete trench laid under the footway. The culverts are constructed of cement concrete, the wall in no case being less than 6in. thick and the bottom 4in. They are covered with York stone bedded in cement, and the culverts are rendered inside with cement, thus making it thoroughly waterproof. Boxes are built every 15 yards along the trenches, and these are the only places in which the cable is supported, so that the insulators are always open for inspection. The insulators are mounted on oak cross-bars (which are mounted on the concrete about 2in. off the bottom) and are made with a notch in the top on which the conductors rest. The culverts are connected, where possible, to the main drains. It might be thought that a film of moisture would collect on the insulators, thus giving rise to considerable leakage; the electrolytic action of the current, however, is said to be sufficient to resolve this moisture into its two component gases. We seem here to have a system which combines most of the desired qualities in a system of mains. However, this has its drawback, like all others. Firstly, in many of our great cities it is impossible to find room for this class of conduit, and then recourse is had to insulated cables. Secondly, a water-main bursting might possibly cause a stoppage of the supply; this, however, is not very likely to happen. Thirdly, gas is apt to accumulate in the conduits, giving rise to explosions. It is, however, less likely to get into a watertight conduit than into a system of iron pipes where there is no attempt made to keep out the water. Whether bare conductors are more likely to ignite the gas is a much-debated question. Only recently two of the technical papers had an article on the subject. One said it is

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easy to see how the gas gets into the conduits, but what fires it? The other, however, wondered how the gas got in, but understood how once in, it was fired. Personally, I am inclined to believe that most explosions occur from lighted matches, candles, etc., being introduced into the boxes. As regards the life of this culvert system, it seems that we have at least got hold of materials which have stood the test of time—viz., oak, concrete, and copper.

I have dealt with this subject in a very sketchy manner, but time does not allow for more. To go into the details of each system would require a paper as long as this. I should have liked to mention some points connected with the use of concentric and triple concentric cables, and the effect of an alternating current in increasing the virtual resistance of the conductor, as also the question of dry core telephone cables, but unfortunately time does not permit. I trust that this paper may prove of interest to the members of the society.

THE FIRST THREE-PHASE TRANSMISSION PLANT IN THE UNITED STATES.

An example of a successful power-transmission plant operated on the three-phase system is that recently installed at Redlands, Cal., by the General Electric Company of New York, who have sent us the annexed description and illustrations. It is the first plant in the United States in which this system is employed. In few regions is water power more appreciated, and electrical power transmission more necessary, than in Southern California. For irrigation alone a water right there is better than most gold mines, for in spite of its marvellous sub-tropical climate artificial irrigation is a necessity almost everywhere. Without it much of the country would be barren and forbidding; with it, it becomes a fertile garden spot. Add to this indispensable irrigation the possibility of using the same water for the distribution of power over a region where coal is from 8dol. to 12dol. a ton, and the importance of electrical power transmission is evident enough. The first water power in Southern California to be utilised for the distribution of power, as well as light, is that situated at the mouth of Mill Creek Canon, nine miles from the city of Redlands, one of the most flourishing of the younger cities of the State.

Less than two years ago a few of the public-spirited citizens of Redlands saw the chance of utilising the fine Mill Creek power, and organised a company, chief among the members of which were Messrs. George N. Crafts, H. H. Sinclair, F. G. Feraud, and George S. Ellis, who have in other ways played an important part in the development of this city. The enterprise was rapidly pushed forward, and about nine months ago a contract was closed with the General Electric Company for the necessary apparatus. The hydraulic part of the installation is of more than usual interest. Mill Creek is a fine and unusually reliable stream that springs from the slopes of mountains San Bernardino and Gratback, the two loftiest of the Sierra Madre range. The main body of the stream and a convenient intake was found near the mouth of the canon, and by comparatively small deflecting dam of masonry, 40ft. long and headwards, it was possible to turn the water into a tunnel, 160ft. in length, cut through the rock, and thence into a heavy steel pipe line, which was brought down the stream a distance of 7,250ft., where was obtained a convenient site for a power-house. At the end of the tunnel is a sand-box, 75ft. long by 25ft. wide, to catch any sediment before the water can enter the pipe line. At this point the fall is in the neighbourhood of 353ft., giving exactly 160lb. pressure to the square inch in the receiver that terminates the pipe line, which can deliver 2,400 cubic feet of water per minute.

The power-house, shown in Fig. 1, is for the most part an excavation not far from the back of the creek, made in a singularly heavy rubble composed of large water-worn stone, very compact and dry. The roof is erected on very low side walls, and under the lean-to on the right is the wheel-pit, with receiver and Pelton wheels. The wheel shafts extend to iron shutters set in windows in a mass of rubble retaining wall that bounds the wheel-pit, into the dynamo-room, where they are directly coupled to several machines. This dynamo-room contains the following apparatus, as may be seen from Fig. 2, which gives an excellent view of its interior: two 50-kilowatt 10-pole three-phase generators, delivering current directly to the lines at 2,500 volts between lines, two D 10 exciters, each capable of energising the fields of both generators, and one 50-light 2,000-c.p. Thomson-Houston arc dynamo. With the stream at its lowest 800 h.p. is developed at the generators. Room is left and foundations are in place for a third three-phase generator and a second similar arc machine. The large generators run at 600 revolutions, give 6,000 alternations per minute, and have a rated output of 100 amperes at 2,500 volts. The general arrangement of the station was planned before the contract for the apparatus was let, and, in fact, before the character of the machinery was determined, substantially according to the designs of the late A. W. Becker, whose recent death was a substantial loss to the electrical interests of the Pacific Coast. To each of these large machines just mentioned a Pelton wheel is directly coupled, the three-phase generators being supplied with 200-h.p. double wheels, each operated by a double nozzle. The regulation of the hydraulic power is by the ordinary differential nozzle operated by Pelton differential governors, driven from one of the exciter shafts. A second small differential governor, driven from the other exciter shaft, steadies the action of the first by regulating the exciter wheels. The water having done its work is discharged into a ditch and utilised for irrigation purposes. On the side of the dynamo-room, opposite the dynamos, are located the switchboards. The chief interest of these lies in the three-phase switchboard for the two big generators. This is elaborately devised to meet every condition or combination that it might be desired to make with the two machines and the two circuits that run from the power-house. Either machine can be thrown on either circuit, and both machines in parallel on either or both circuits. At present the parallel connection is chiefly used in shifting over the load to one in perfect continuity of service. A six-ton travelling crane permits ready handling of any of the machinery. The interior of the station is a model of its kind. Particularly to be noted are the excellent foundations which are carried deep down into the solid rubble, and are built up with a liberal supply of cement, sharp gravel, and small stones. In the upper portion of the foundation equal parts of cement and gravel are used, and the top layer is of pure cement. To this smooth surface is bolted a framework of oak about 3in. thick. On this rests the dynamo, which is secured to it by bolts firmly screwed up and bedded in sulphur. The result of this careful foundation and excellent alignment of shafts is that the large generators run without even a tremor at the bearings.

The whole fitting of the station is admirable, and the same care is extended to the little house of the engineer (seen in Fig. 1), which is lighted from one of the exciters, and is to be furnished this winter with electrical heating and cooking apparatus. From the power-house are run two three-phase circuits, each composed of three 00 B. & S. wires. One of these runs to the company's office, at Redlands, a distance of 7½ miles, and from thence is distributed over the city for lighting and power purposes. On a substantially built pole line the other extends to Mentone, 4½ miles, where is located the artificial ice plant of the Union Ice Company. In this plant is installed a self-starting 150-kilowatt triphase 750-revolution 6,000-alternation synchronous motor, belted through the medium of a countershaft to two large compressors for the ammonia, a circulating pump for the compressor jackets, a force pump to supply water for the ice, and a small elevator for handling the ice. In order to ascertain the point of synchronism, a Thomson acoustic synchroniser is employed, and gives unqualified success. The ice plant is of the so-called "Pipe" type, and the freezing-room and condensers contain nearly 20 miles of ¾in. iron pipe, in testing which the motor was stopped and started at short intervals for several weeks. The operation of the ice plant is continuous, the load being on the motor 24 hours a day, and, barring accidents, 365 days a year. The motor plant at this point is likely soon to be increased to keep up with

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an increase in the plant. From the main Redlands circuit a number of lines are taken off the ice plant, and also for the neighbouring town of Mentone. There are now in operation 30 arc lamps, besides over 1,000 16-c.p. incandescent lamps distributed over three lengths of legs of the circuit. A number of small induction motors

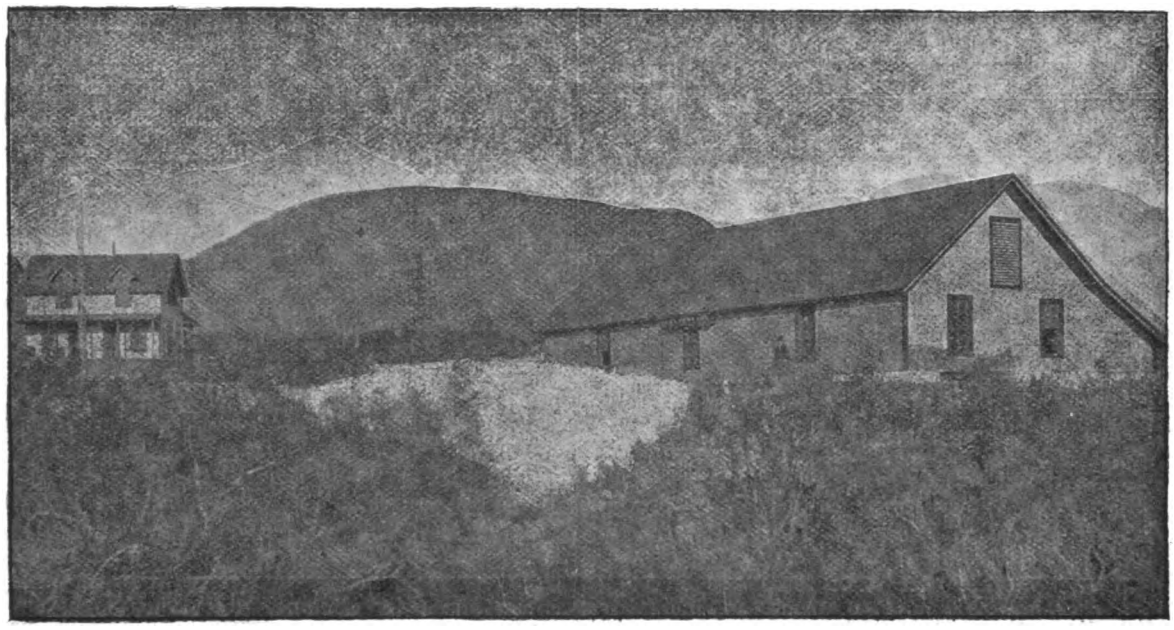

FIG. 1.—The Power House at Redlands.

without commutators or collecting rings are to be installed shortly, to meet the demand already created by the success of the plant. The transformers are very similar to the ordinary General Electric type T transformer, except that they are designed for 50 cycles per second, and to reduce the pressure from 2,200 to 110 volts. So far as possible, rather large transformers are used with comparatively long secondaries. These are used only directly at the point where light and power are delivered.

No trouble whatever has been experienced from any unbalancing of the lighting lines. In fact, shortly after the plant was started, the largest single block of lighting in the city, wired for three circuits, had these circuits worked for several nights on two legs of the triphase generators, pending the setting up of the third transformer, and although the lights from these two legs were set in adjacent rooms, where both would be seen at once, not the slightest trouble from unbalancing was evident. The first generator reached Redlands on September 1, and on September 7 incandescent lamps were turned on in Redlands, where arc lamps had been previously working since the latter part of July. On September 13, the motor at the ice plant went into commercial operation. The whole plant has been running steadily, and doing good service ever since.

The plant has now been in thoroughly successful operation, and the General Electric system and apparatus has given entire satisfaction, for several months; and with the progressive and business-like management of the company bids fair to be not only a succesful power transmission, but an eminently satisfactory investment. Its operation has been singularly free from difficulties of every kind, and it appears to be a thorough demonstration of the adaptability of the General Electric Company's three-phase system to the work of transmission for both power and lighting.

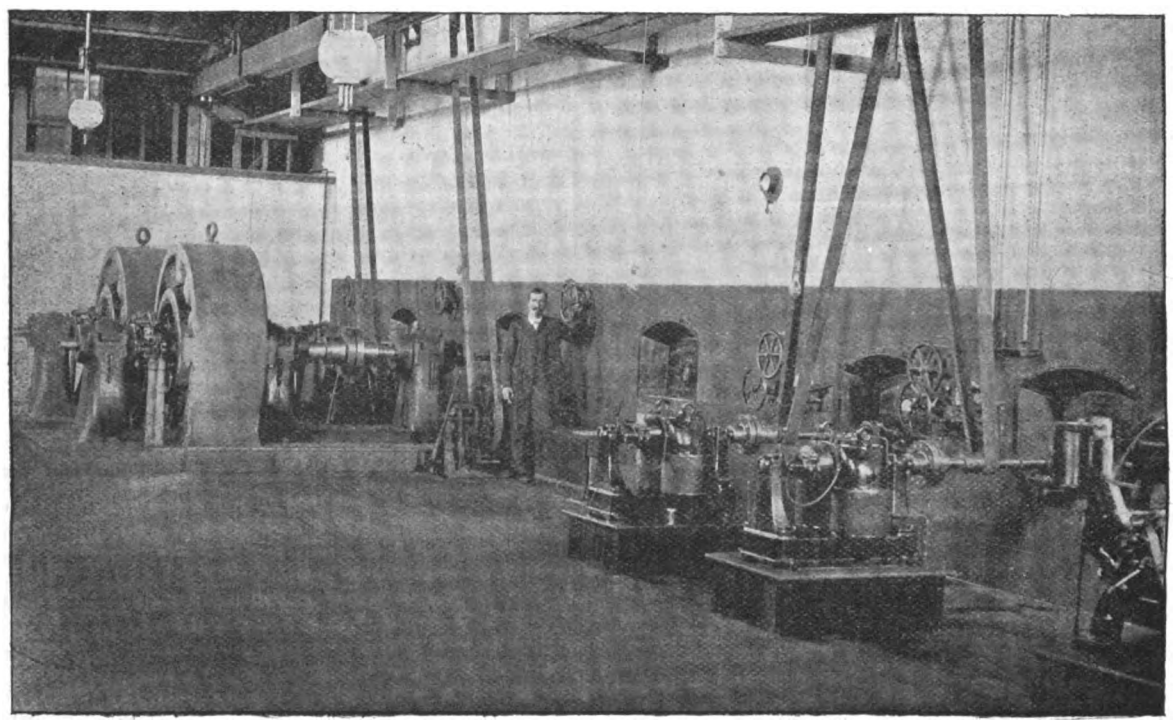

FIG. 2.—Internal View of Dynamo Room at Redlands.

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THE
ELECTRICAL ENGINEER.

Published every Friday.
Price Threepence; Post Free, Threepence Halfpenny.
Editorial and Publishing Offices:
139-140, SALISBURY COURT, FLEET STREET,
LONDON, E.C.

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TO CORRESPONDENTS.

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THE GUILEFUL PATENTEE.—II.

Our correspondent Mr. Fitz-Gerald is probably correct in his conclusion that our article of last week was too sweeping in its condemnation. He agrees with us, however, in anathematising a certain class of inventors and patentees, and we think this class includes by far the greater number of patentees. There are exceptional cases, and exceptional cases need exceptional treatment. It is true that the company promoter has, to the detriment of the patentee, lined his own pockets with cash while the originator has had to be satisfied with a small sum, hardly enough perhaps to keep him from starvation for a month or two, with additional promises in the shape of dividends to come on shares. Too often the whole scheme has fallen through as soon as the promoter obtains satisfaction, or the value of the shares has been reduced to nil by the issue of preference shares and debentures. We agree to all this. In our eyes the company promoter is a kind of necessary evil in civilised states—an evil which has to be tolerated and kept under as much as possible, inasmuch as the tendency of the evil is to grow worse and worse, till it becomes a method of gigantic swindling. The company promoter is worth his fair pay, but when what he takes goes beyond this, nothing good can be said of him. If it becomes the duty of a technical journal to discuss these questions, it is only because the avaricious greed of the promoters connected with the technical applications has been so disgraceful that further danger must be averted by plain speaking. Spencer Balfour's name is in the mouths of everyone, and he is looked upon as a pariah even among promoters; but we think this general feeling is due to deliberate attempts on the part of folks as bad, or worse, than himself to paint him blacker than he really is. Bad as we know this man to be, we imagine the revelations to come will show that others who are now bespattered by flatterers and sycophants will be shown to be worse. The crust of the investigation into trust companies has only been broken. When we get further and know who really started these affairs—who, for example, was the biggest holder of founders' shares in such places as Winchester House—and pursue the ramification of their workings, there will be more astonishment in the City than has been seen for many a year. We are credibly informed that the evidence is almost complete, and may descend like a thunderbolt at any minute. Probably, however, Mr. Spencer Balfour holds some of the threads wanted, and his much-wished-for arrival in this country will be the signal for some startling revelations. We only refer to this matter because, among other things, Mr. Spencer Balfour was mixed up with some electrical companies, and in one case especially very large sums went among the promoters. But what has all this to do with patentees? Merely to show that some promoters are on a par with some patentees. We must, in the face of Mr. Fitz-Gerald's letter, except that very small class which unfortunately suffers nothing but hardship, both on the side of the patentee and the promoter. As a

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rule, the bigger the swindle and the bigger the liar, the easier to obtain money; while those desirous of real work and real improvement find it extremely difficult, nay, often impossible, to obtain their modest and moderate requirements.

We cannot, however, even while admitting the hardship to the honest, earnest, masterly patentee, budge from the broad conclusions of our article. It is only in exceptional cases that the patentee cannot get his supposed improvement carefully considered by the management of the large manufacturing companies. It is in the interest of the management to obtain improvements. One thing, however, is far too often forgotten by the patentee who is outside a manufacturing concern. Let us take for a specific example the would-be improver of a dynamo not engaged in a factory. Few of those who fill the files of the Patent Office know and understand the constant experiment that goes on in the factory, the constant thought in the drawing office to the perfection of details; and dozens, scores, nay, hundreds, of the suggested improvements are known to the practical man to be impossible and valueless. The patentee in submitting his scheme is told so, but he doesn't believe one word that is told him, and immediately sets out to go the round to induce someone to advance money to give his patent a trial. Study the Patent Office specifications and see how few contain even a germ of improvement. Hundreds are filed by men who have only the most superficial knowledge of the subject, and are for things that have years ago been tried and found wanting. It would be interesting to know how many patented improvements have been offered to and rejected by, say, Messrs. Sellon and Raworth, Mr. Crompton, Messrs. Johnson and Phillips, Messrs. Siemens, and other of our large firms. If such statistics could be given, we think our contention would be proved to the hilt—that the majority of patents are utterly valueless, that the majority would be considered by such firms as we have named, and that the residuum of valuable inventions not taken up by such firms is small. The hardships undergone by this small residuum is, nevertheless, a real hardship.

STEAM-ENGINES FOR CENTRAL-STATION WORK.

A pudding may be considered highly satisfactory when jaded appetites have made a clean sweep of it, and this well-known statement may serve as foundation for generalising from results in every case. In a very short while, for instance, electrical engineers will probably have obtained such exhaustive and complete results, or working experience, as may enable conclusions to be drawn respecting the most suitable type of prime mover or steam-engine for central-station work: and those who intend to erect and equip large electric lighting plants—whether privately or on behalf of municipalities—during the next few years, cannot watch too carefully the working results obtained from the stations already at work, making due allowance for the varying cost of fuel, etc., in different localities.

At the present time, indeed, it would almost appear as though the most suitable type of steam-motor were already justifying its adoption in comparison with any other of the numerous arrangements experimented with. At any rate, there is a remarkable coincidence between low works cost and the employment of high-speed compounded steam-engines of the inverted vertical form. We do not of course assume any casual connection whatever between these two circumstances: their concurrence in so many cases may be due to chance, and chance only; but if the continued adoption of such motors should always result in a low working cost, there would be strong justification for examining into the matter with a view to prove the connection or not. There are naturally several complicating conditions, one of which—the relative cost of fuel—we have already mentioned. Besides this, the system adopted, alternating or continuous current, the methods of distribution, and the character of supply area, etc., must all have undoubted influence upon works cost per unit. Separating these, however, as far as possible, it is, we think, well worth while to look into the question of prime movers in order to find the best and most economical type for long service. It may not be out of place to suggest a comparison between the high-speed vertical engine and the slow-running horizontal type with Corliss or other quick-acting valve gear. Seeing that the average load factor of electric light stations is at present so extremely low, the latter type of engine has many disadvantages, not the least of which is its comparative inefficiency when running much under load. Their small range of cut-off is largely responsible for this. Probably it may be found that a combination of engines will best serve the purposes of an electric supply station: high-speed vertical engines—compounded, of course—for the light loads, and heavy, slow-running horizontal motors for use at times of full load.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

INVENTORS AND PATENTEES.

SIR,—Although there is one class of inventor and patentee—a man ignorant and impudent, who works in the dark and invariably preys upon ignorant members of the public—who should be extirpated by every possible means, I think that the general tone of your leader on "The Guileful Patentee" is unfair and one-sided. If this be so, a very large section indeed of your subscribers and readers—those who are more or less interested, from various points of view, in invention and patents—have cause to complain. But especially the honest, enthusiastic, and laborious, albeit "impecunious," originator in the domain of applied science may consider himself aggrieved; for he can have no doubt as to your grim intent to starve him out of existence, if that can be done by writing him down. This would be hard upon inventors, for, to parody a passage in your leader, many have been long years at work, and, by study, intelligence, and industry, have embodied such valuable ideas in a patent or patents that they might fairly expect a competency to result therefrom.

The inventor is usually a patentee, because the patent laws afford him almost the only opportunity he usually

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has of making any profit out of his inventions—*i.e.*, of turning to account his training, time, and labour. And who can estimate the benefits conferred upon the community by the inventor—thinking, experimenting, labouring with brain and hand, by day and by night, and often, alas! starving, whilst the astute man of business reaps the benefit of the initiative taken by men of a higher order of intelligence working for all humanity. Paccinotti, Goodyear, Bessemer, Gramme, Faure, Gaulard, S. Varley, and many who have fallen unknown—where should we be without them?

In regard to dupes, the originating inventor seems often to be regarded as fair prey for anyone having the "gift of the gab" and wit enough to pirate or over-reach. Have you never heard of an inventor parting with his patents in consideration of a large sum—in shares afterwards rendered valueless by the issue of "preference shares"? Have you never heard of an inventor being fleeced, not only of his patents, but even of the credit attached to his inventions? If not, you can hardly realise how much there is to be said on that side of the question you have left out of consideration. There is plenty of work also in running down sham inventions and non-valid patents—too often turned to profitable account—whilst inventions of real merit are neglected.—Yours, etc.,

DESMOND G. FITZ-GERALD.

TESTING THE HYSTERESIS IN IRON.

SIR,—In your issue of March 3 you gave Mr. Kapp's very interesting method of, in workshop practice, measuring the hysteresis in the iron plates used for transformers and armatures. As was pointed out, what is wanted is not so much absolute measures of the hysteresis as relative ones, so that the manufacturer can compare different samples of iron and can ensure that he is getting iron of uniform quality. We have for some time past used a very simple method of comparing different samples of iron depending on the rise of temperature of the sample when subjected to an alternating magnetic field.

Two solenoids on wood frames, and identical in every respect, are coupled in series on an alternating circuit. Into each of these a core is put consisting of a definite weight of iron plates, insulated from one another with paper, and having in the centre a piece of wood with a slot for a thermometer. One of these cores is prepared of plates which are considered standard, and the other of the plates to be tested. Readings of the thermometers are taken at intervals, and the one which shows least rise of temperature is considered the best iron. The induction in the iron can be varied both by varying the E.M.F. on the coils and by varying the weight and number of plates in the cores. The whole apparatus is so simple that it can be worked by an intelligent apprentice.

We may say that we have found no advantage to be gained in annealing the plates as obtained from the makers, but unless insulated from one another by some medium such as paper, the loss is largely increased.—Yours, etc.,

C. A. PARSONS AND CO.

Heaton Works, Newcastle-on-Tyne, March 12, 1894.

RUNNING IN PARALLEL.

SIR,—I think Mr. Metzger's letter *re* "Running Alternators in Parallel" calls for one or two remarks.

If you are running alternators in parallel you should have a sufficient number in, so that in the event of anything happening to one the other machines will not be seriously overloaded. But should this be the case, you could then switch off a circuit till another machine was put in, although I think it is far better to run the whole system at a slightly lower voltage than to have any one part of it totally extinguished.

Mr. Metzger's circuits must be very nicely arranged so that he can load each machine up to its full capacity, and unless he can do so it is better to run, say, six machines in parallel at 80 per cent. of their full capacity than to have some running about 50 per cent. and some 100 per cent.; and, again, you can pull out your machines as the load goes off, whereas in the other way you have to wait till each machine has no more than half its load before you can transfer the circuit on to another machine, and unless the machines are put in parallel to do it you cause a great fluctuation in the light.

Surely, Mr. Metzger, citing the case of the Bankside breakdown, must know better than to think that 75,000 lights are run on one pair of mains.

The Brush Company have devised an apparatus for cutting out an alternator should the current run back on it from any cause whatever.

A. G. C.

London, March 10, 1894.

REVIEWS.

The Engineer's Year-Book of Engineering Formulæ, Rules, Tables, Data, and Memoranda in Civil, Mechanical, Electrical, Marine, and Mine Engineering. By H R. KEMPE, A.M.I.C.E, M.I.E.E. First year of publication. Crosby Lockwood and Son.

This is a book somewhat after the style of Molesworth, which, owing to the continuous changes in many of the data, it is proposed to correct and publish annually. It has been impossible to examine very closely into the numerous figures and formulæ contained in a closely-printed book of nearly 600 pages, but the position and ability of the editor make it certain that the greatest care and attention have been given to ensure accuracy. There is one feature of this book to which we decidedly object—not connected with the editor, but with the publishers. Men do not buy books of this kind to be bothered with advertisement pages inserted in the text. Advertisers will gain little or no benefit, because busy men will simply tear out these inserted advertisement pages, leaving those legitimately placed at the beginning and end of the letterpress. The electrical engineer's duties are inextricably connected with mechanical engineering so that, as a rule, a pocket or year book devoted solely to electrical figures and formulæ is not what he wants. But his requirements are of a more general kind; perhaps some will think not quite so wide as this year-book, though we think the wider information is on the right side. We contend, then, that electrical engineers will find this work useful, even though it has but a comparatively small section devoted directly to electricity. A book of this kind needs a very exhaustive examination before it can be said to be complete, and this we have not yet been able to give it; but so far as a brief examination is concerned, we find the information such as is wanted, it is given in a clear and concise form, the diagrams and figures are correct and up to date, while the index, were it not for these bothering interpolated advertisements, is very good.

A Text-Book on Electromagnetism and the Construction of Dynamos. Vol. I. By Prof. D. C. JACKSON, of Wisconsin, New York, and London. Macmillan and Co. Price 9s.

We must confess that the price of this book seems excessive, especially when it is considered that the author admits: "No special originality is claimed for the matter presented except in certain details; but it is hoped that the logical arrangement, and the omission of all unnecessary details, will make the book of so convenient a form as to lead to its general endorsement as a satisfactory text and reference book." We may endorse the verdict that this is a satisfactory text-book for college classes, while saying that the cost is too great. It is possible to pay too much for a good thing, and when we consider again that this volume does not touch upon alternate-current machinery nor series arc lighting machinery, but that these subjects are reserved for a second volume, we think our protest justified. The authorities consulted by the author are duly acknowledged. There is no doubt but that the author has carefully examined and condensed into this treatise the very latest information, and that for the special purpose for which the book is designed he has produced an excellent work. It is, of course, more mathematical than physical. Many of the chapters are exceedingly clear, and must render the task of the student much lighter than when he has to seek for conclusions among the original memoirs.

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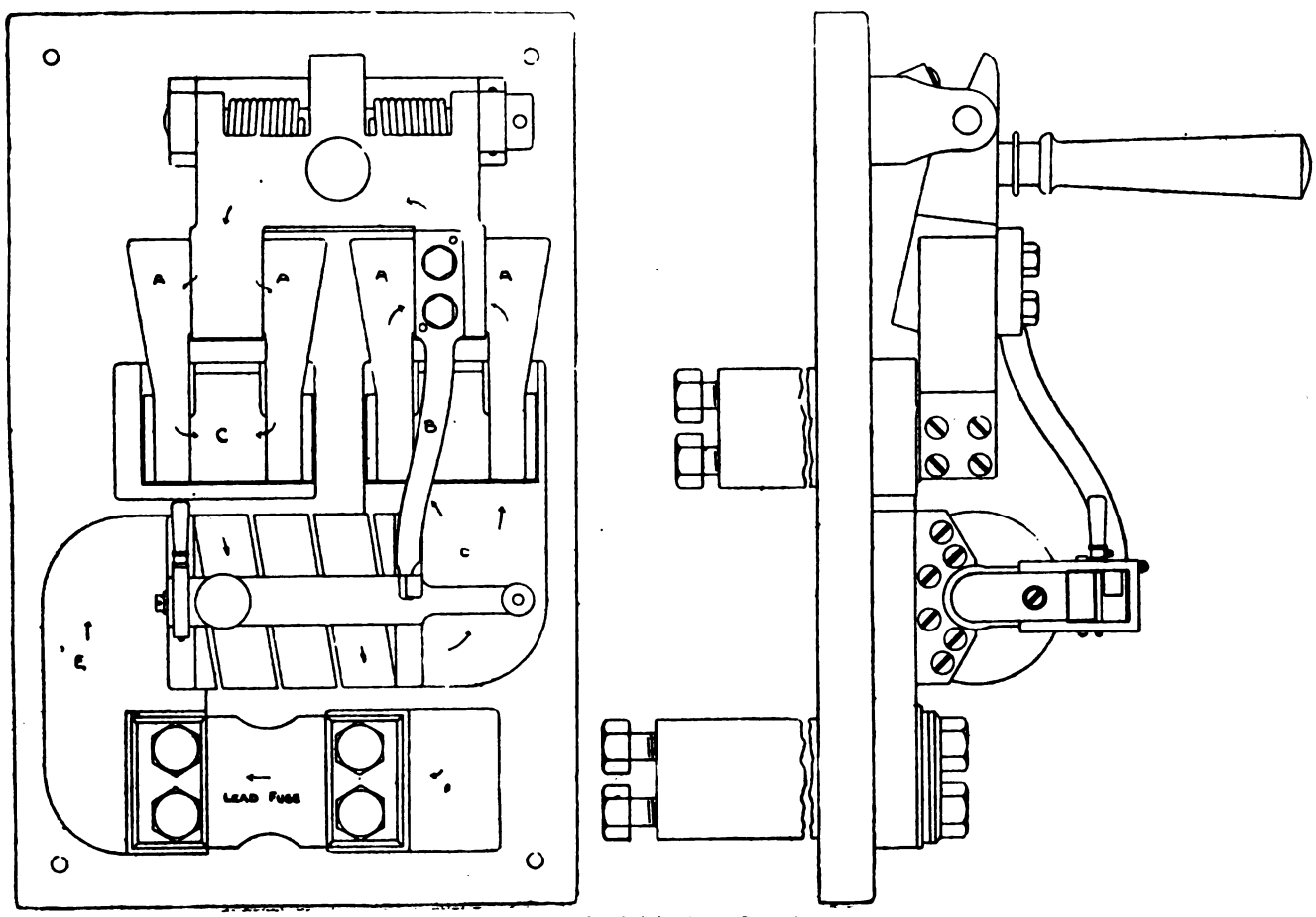
AUTOMATIC CUT-OUT FOR LARGE CURRENTS.

In a recent issue (see the *Electrical Engineer*, 2nd inst., page 258) we described and illustrated a large new main switchboard now in course of erection by Messrs. Siemens Bros. and Co., Limited, at the Carnaby-street station, belonging to the St. James and Pall Mall Electric Supply Company, Limited. On this board are fixed several massive automatic cut-outs for large currents, one being provided for each machine feeding into the omnibus bars. The details of these given in the article referred to were, however, not perhaps sufficiently minute to enable our readers to clearly understand their design and construction. We therefore append illustrations showing in outline form the front and side views of the automatic cut-out thus employed to carry 1,500 amperes as a maximum. The course of the current through this appliance is shown in the front view by arrows. It enters at F, from massive terminals at the back, taking two cable leads. From the brass block, F, it passes through a lead fuse to another block, E, connected to one end of a heavy copper solenoid, round which the current travels to another block, D. On the latter are mounted the laminated spring contacts, A A, between which the contact-piece, with arm, B, is pressed down. The current then passes through the heavy swinging switch block at the top of the appliance (pivoted as shown, and provided with powerful coiled springs tending to force it outwards, so as to break contact), down the other arm, through a similar contact-piece, to a second set of laminated spring contacts, and thence to the front block, C, with massive out-going terminals at the back. The solenoid is provided with an armature and a catch, by means of which the lower end of projecting bar, B, may be held so as to retain the switch blocks in contact, in the usual way. Strong handles are fixed in the main switch block and armature frame for the purpose of replacing these by hand after being thrown out. There is also a pin in the framework at one end of the solenoid by which the armature may be fixed in position if it is desired at any time to work non-automatically. A stop block is provided at the top of the instrument, with indiarubber cone, to limit the action of springs when throwing forward the switch block and arm, B.



Automatic Cut-Out for Large Currents.

ON THE DESIGN OF ELECTROMAGNETS FOR SPECIFIC DUTY.—II.*

BY E. R. CARICHOFF.

Electromagnets may be designed, as was shown in a previous article, with a certain length of air-gap, which, if multiplied by the pull between the armature and the poles separated by this air-gap, gives a maximum. The length of this air-gap is different for different values of the magnetic induction, and may readily be determined.

For example. Suppose the magnet to be made of cast steel, the $\mathfrak{B}$ $\mathfrak{H}$ curve of which is furnished by the Syracuse Steel Foundry Company, and plotted in Fig. 1 as curve 1.

Draw a tangent to any point of curve 1, and parallel to it draw a line through the origin, then the point where this parallel cuts the horizontal line drawn through the point of tangency is one point of curve 2, the abscissæ of which represent the magnetomotive forces for different values of the induction in the variable air-gap above defined divided by the length of the magnetic circuit in the steel.

The abscissæ of curve 3 represent the length of these variable air-gaps in ten-thousandths of a centimetre, corresponding to different values of the induction, $\mathfrak{B}$; also for each centimetre length of the magnetic circuit in the steel. The successive points of this curve are determined from those of curve 2 by dividing each abscissa by its corresponding ordinate.

Curve 4 is plotted from a table that is given in S. P. Thompson's book on "Magnets," and was calculated from Maxwell's formula,

$$P = \frac{\mathfrak{B}^2 A}{8\pi},$$

using such units that the abscissæ are pounds per square inch of polar area instead of dynes per square centimetre.

* From the *Electrical World* (New York).

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Denote the abscissæ of curve 4 by P in pounds, those of curve 3 by L in ·0001cm., the length of the magnetic circuit in the steel by l in centimetres, and the polar area by A in square inches. Then work, being defined in this case as initial pull times travel, is expressed by

$$W = P \times L \times l \times A.$$

Assume W to be 10 centimetre-pounds, then

$$A\,l = \frac{10}{PL},$$

and the values of $\frac{10}{PL}$, corresponding to the successive ordinates, $\mathfrak{B}$, give the abscissæ of curve 5. $A\,l$ is a volume in which l is in centimetres and A in square inches, and this is seen to be proportional to the work, as above defined, which the magnet is capable of doing.

To illustrate the use of curve 5, suppose it is required to move a lever arm a distance of one centimetre against a pull of 100 pounds, W = 100 centimetre-pounds.

Assume $\mathfrak{B}$ = 13,500. We see that for this value of $\mathfrak{B}$ and for W = 10 centimetre-pounds, $A\,l$ = 18·5; for W = 100 centimetre-pounds, $A\,l$ = 185. Of course, we may give to l or A any value we please; but as the magnetomotive force, $\mathfrak{F}$, varies directly with l, there is economy in making A large and l small—just long enough, in fact, to permit the necessary winding.

As an example, try l at 20 centimetres and A at 9¼ square inches. The total magnetomotive force becomes

$$\mathfrak{F} = 20\,(18{\cdot}3 + 70) = 1{,}766,$$

and the ampere-turns are about eight-tenths of this, or 1,420. If these dimensions do not afford sufficient space for proper winding it will be necessary to increase l.

The total length of the air-gap will be

$$L\,l \text{ or } {\cdot}00515 \times 20 = {\cdot}103 \text{ centimetre.}$$

If the air-gap is divided into two variable parts, it is evident that the movement of the armature can be only one-half of the total air-gap, and a 20 to 1 lever will be required to move the 100lb. over a distance of one centimetre, as required. But if one air-gap only is variable, the other being an almost negligible constant, a 10 to 1 lever will suffice.

A form of magnet sketched in Fig. 2 will afford one constant and one variable air-gap. The constant air-gap at the neck of the magnet may be made very short and of large area. The upper cylinder is guided by the brass ring at the neck and by the brass rod sliding in the lower cylinder.

The accompanying table has been arranged partly from the curves above and partly from calculations on the slide rule. It shows some very interesting relations.

If it is desired to move the lever arm against the increasing force of a spring, the magnet may be made to balance this force at two points of its travel by selecting the induction to give the required pull at these two points.

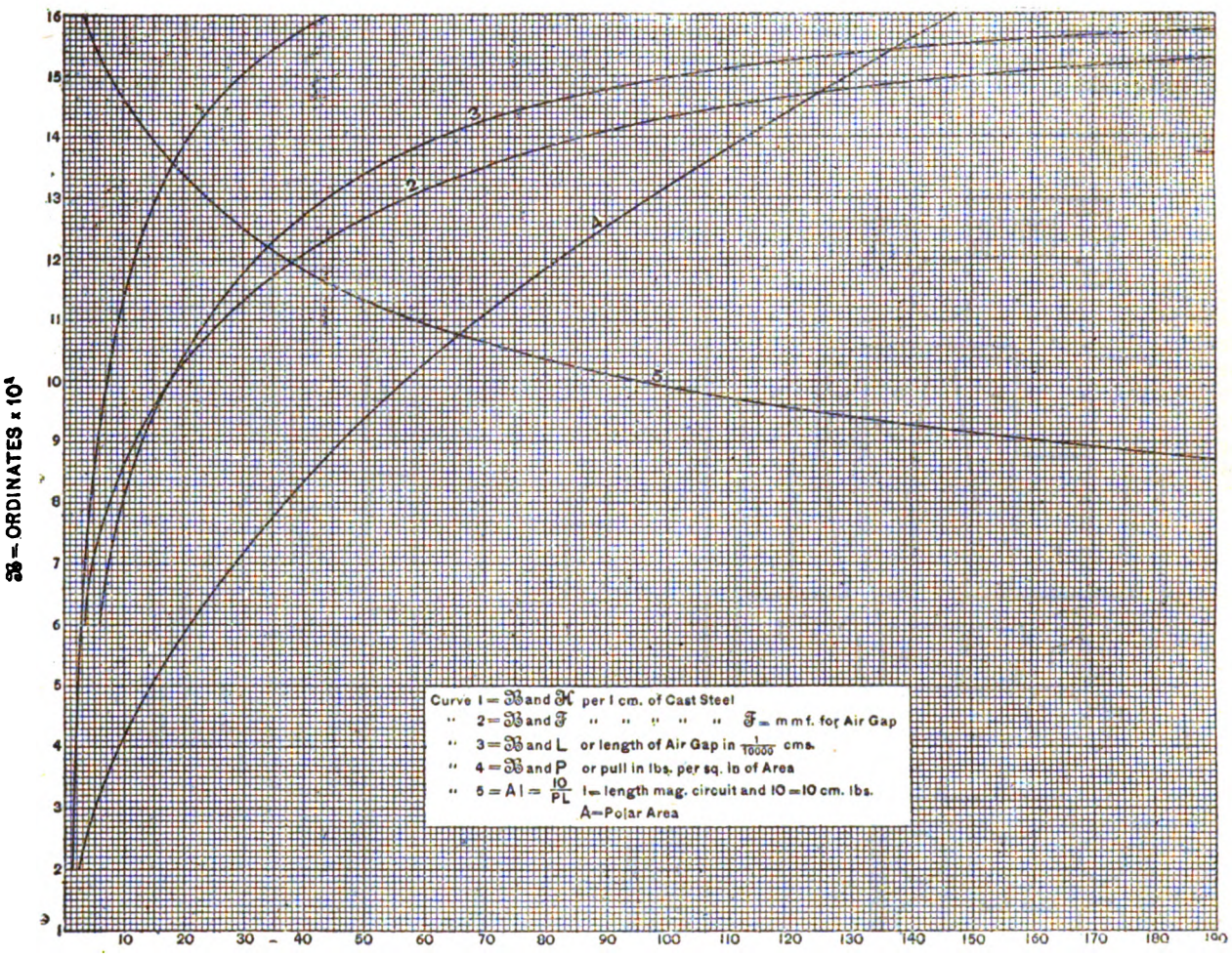
𝔅 = ORDINATES x 10³
Curve 1 = 𝔅 and ℋ per 1 cm. of Cast Steel
" 2 = 𝔅 and ℱ " " " " " " ℱ = m m f. for Air Gap
" 3 = 𝔅 and L or length of Air Gap in 1/10000 cms.
" 4 = 𝔅 and P or pull in lbs. per sq. in of Area
" 5 = Al = 10/PL l = length mag. circuit and 10 = 10 cm. lbs.
A = Polar Area

FIG. 1.

𝔅	P.	L.	P × L.	$\frac{10}{P \times L}$	ℱ for 1 cm. of steel plus ℱ for air gap defined.	Values of l for ℱ = 1,000.
8,000	37·	·00097	·0358	279	12·8	78·2
8,500	41·5	·00112	0465	215	14·8	67·7
9,000	46·7	·0013	·0607	164	17·4	57·6
9,500	51·9	·00152	·079	127	21	47·7
10,000	57·7	·00176	·1015	98 5	25	40
10,500	63·5	·00205	·13	76 5	30	33·3
11,000	69·8	·0024	·1675	60	35·7	28·0
11,500	76·2	·00278	·212	47	42·5	23·5
12,000	83·1	·00324	·269	37·3	50·4	19 8
12,500	90·	·00374	·337	29·8	60·4	16·6
13 000	97 5	·00437	·426	23 6	72 2	13·9
13,500	105	·00518	·545	18·3	88·4	11·3
14,000	113·1	·00625	·707	14·1	108·7	9·2
14,500	121·4	·00778	·946	10 6	137	7·3
15,000	129·7	·01015	1·315	7·73	184	5·45
15,500	138·8	·0146	2 02	4·93	260	3·78

Much of this article and of the one preceding has been presented in the form of suggestions, which may be elaborated to suit individual cases.

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The main facts that seemed to the writer as useful are that there is a certain length of air-gap for any given magnet of uniform cross-section where the pull between armature and poles is lessened if the polar area is either increased or diminished, and that the pull under these conditions, multiplied by the length of this air-gap, is greater than the pull with any other air-gap multiplied by the length of the latter.

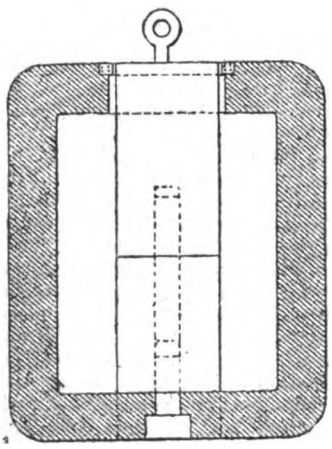


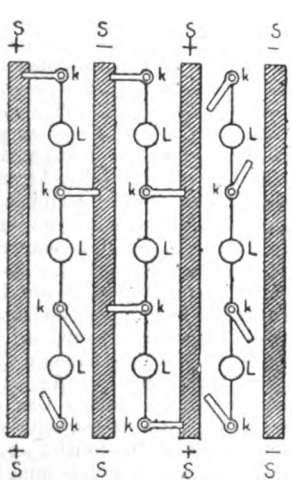
FIG. 2.

The use of different systems of units may seem objectionable to some, but when accustomed to the calculation of magnets in pounds per square inch the term grows to mean something more definite to the average worker than dynes per square centimetre. It is a simple matter to change the relation, and those who prefer the use of the same dimensions throughout may pass a pleasant hour in drawing curves to suit the units they prefer.

HEIMS'S LAMP RHEOSTAT.

The use of lamps as a means of regulation, and even of testing, is attended with many advantages; a notable feature being freedom from induction. Herr Heim has arranged a lamp rheostat which combines the following qualities: (1) a single lamp, or a series of incandescent lamps can be subjected to widely varying pressures; (2) the resistance is variable, and may be graduated to any desired extent.

The lamps are placed in a certain number of rows, each row being in series. In the figure three such rows are shown with three lamps, L, in each. At both sides of each row are two bars, S S, and by means of the switches, K, which make contact between the lamps and bars, a great number of combinations may be made. When a switch



forms a right angle with the bars it is in connection with them. When the angle is from 30deg. to 60deg. it does not make contact. To arrange the lamps in parallel as in the illustration, all the bars are connected alternatively with the positive and negative poles of the source of current, and the switches placed on the bars left and right. The middle row is joined up in this manner. Each of the switches carries a current double that necessary, and supplies the lamps on each side of it. In this way all the lamps are in parallel, and any lamp may be cut out by a simple movement of a switch.

If the pressure is found to be excessive, the lamps can be grouped in series parallel. The two switches at the ends of each of the two groups may be placed on the bars as long as the intermediate handles are not in contact with either of them. The pressure will then be found greatly in excess of that required for one lamp, but if it does not exceed double the proper value, and is between the one and the other, the groups of two lamps in series may be inserted in parallel. In the same way, groups of three, four, or more lamps may be inserted in parallel until all the rows of lamps in parallel are taken in. In case, however, the pressure in any bar is still too great, more lamps can be grouped in series than are contained in one row. In fact, there is hardly any end to the various ways in which the lamps can be grouped in single parallel, in series, or multiple series, but we doubt very much if the apparatus will come into extensive practical use.

ELKHART TRANSFORMER.

The Elkhart transformer is of the tooth type, and one of its principal claims for attention is that the coil may be removed, inspected, and replaced in a very short space of

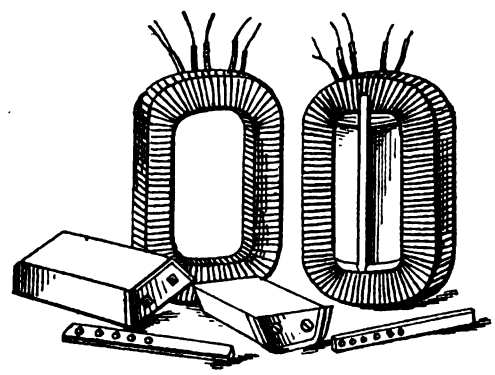


FIG. 1,

time without destroying the integrity of the laminations of the iron. All the coils are interchangeable, and by having an extra coil at hand repairs may be made in an extremely short time. Fig. 1 shows the parts of the transformer,

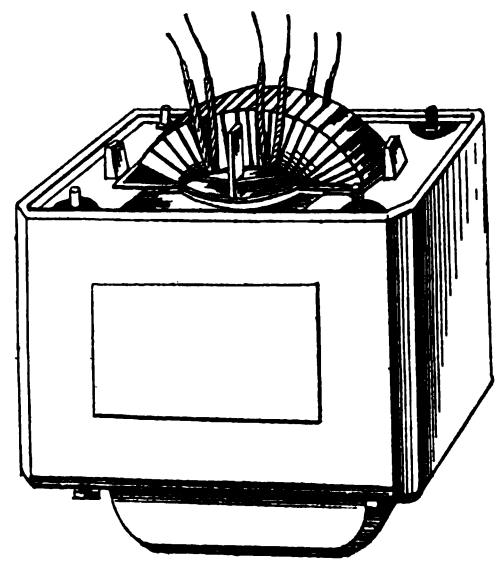


FIG. 2.

and Fig. 2 the appearance of the box ready for service. In the mechanical construction of the converter the outer magnetic circuit is unbroken, the laminæ are placed in the case under hydraulic pressure, thus making them practically noiseless. The core-pieces when placed in position occupy the V-shape cut in the outer laminæ, and by means of the wedges the magnetic resistance is reduced to a

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minimum by practically making each lamination one piece of iron. In the coil construction a compound having high insulating qualities is used, rendering the complete coil practically indestructible and impervious to moisture, the whole constituting a solid mass of wire and insulating compound.

THE UTILISATION OF SMALL WATERFALLS.

M. F. Chédeville, in the columns of a French contemporary, makes some remarks on this subject in reference to a paper read by M. Hillairet before the Société des Electriciens on the utilisation of waterfalls for the transmission of power. He suggests that the water itself should be made to fulfil the functions of an accumulator, and that the ground in the vicinity of the fall would probably be of no great value, and might, in consequence, be utilised for building a reservoir. Variations of water supply would thus be got rid of and a greater output obtained. If, moreover, the ground occupied by the reservoir is sloping, a considerable increase in the height of fall may be obtained, especially if several partial falls have been collected into one. Assuming that each lamp is alight, on the average, for five hours per day—which is certainly too much—then by using the reservoir one would get 15 times more power from the fall than if it were used in the ordinary way only during the hours of lighting, and certainly three times more than with the use of accumulators without the reservoir. There would also be a great advantage in being able to obtain a considerable amount of power on special occasions, without the expense and depreciation of a battery. If high-tension alternating currents be used, and transmitted to neighbouring towns with sub-stations, one is more at liberty to choose an advantageous spot for the reservoir. This system will necessitate the use of larger machines, on account of the increased power of the fall. The machines will be more efficient, and working expenses reduced, on account of the shorter hours of working. As an example of the advantages to be derived from the above system, the author describes one of M. Claude's installations. The necessary power is supplied from one of the tributaries of the River Marne, where, without much cost, a 10-metre fall can be obtained. The village to which it is desired to transmit power is at a distance of 1·5 kilometres from the fall. The surplus power might be utilised by several small villages in the vicinity. The flow was carefully measured several times during a year which included two exceptionally dry periods. The results of these observations are plotted in a curve. The limits of flow were found to vary from 1,300 to 35 litres per second. The average flow was 225 litres per second. During a period of frost it fell to 100 litres per second. If the fall were utilised in its natural condition, one could depend only on 80 litres per second in winter, and with no regularity. Assuming an output of 75 per cent. for the turbine, 80 per cent. for the dynamo, and 90 per cent. for the line, there would be 5·76 h.p. available at the terminals of the lamps, sufficient for 75 16-c.p. lamps. Now, if a battery of accumulators were employed, and six hours be the maximum duration of lighting, the fall would be utilised four times longer, and the available power becomes 16 h.p. during six hours, or sufficient for 240 16-c.p. lamps. The stream under consideration flows in a confined valley about 100 to 200 metres wide; at one point there is a waterfall of about five metres in height, and one kilometre away another fall, with a slope about six metres between them. The valley at the second fall is only about 50 metres wide, thus being eminently adapted for the construction of a dam. The reservoir would occupy an area of 15 hectares, and if we assume a depth of 12 metres, the contents would amount to 1,800,000 cubic metres. Assuming a mean fall of 16 metres, and allowing 75 per cent. efficiency for turbines, 90 per cent. for dynamo, 90 per cent. for line and transformers, 156 h.p. would be available at the lamp terminals, and would therefore be capable of lighting more than 2,300 16-c.p. lamps during six hours in winter and two hours in summer. It is thus possible to obtain 25 times more power than from the fall in its natural condition, and seven times more than with the use of accumulators.

A PLEA FOR SERIES ELECTRIC TRACTION.

BY NELSON W. PERRY, E.M.

During the few years prior to 1879, when the hopes of utilising the electric current for lighting purposes were high but not yet practically realised, electricians were perhaps about equally divided as regarded methods of distribution. The chief apostles of the two schools were Charles F. Brush and Thomas A. Edison. The former advocated the plan of distributing by unvarying current, and the latter by unvarying potential. The former had met with considerable success with the arc lamp some time before the incandescent lamp became known to the public, and, so far as the operation of arc lamps was concerned, his success was as complete as was that of Edison later with the incandescent lamp. While Brush was working with large units intended to be distributed over large areas, Edison was working with smaller units intended for a more limited distribution, and each solved his own problem so satisfactorily that neither method has yet been supplanted in its own territory to any considerable extent by the other, although a borderland between the two territories has been occupied with varying degrees of success by both.

Brush employed a current of constant value, and arranged his lamps in series with each other and the source of energy so that the current passed through each in succession before returning to the generator, the increase of energy required by the multiplication of lamps being supplied by a corresponding increase in pressure at the generating station. This method had at least one recommendation: it admitted of a precise determination of the most economical size of conductors, which held the same relation towards economy so long as the cost of copper and steam power remained the same, whether there were two lamps burning or 50, or whether the line were one mile long or 30. Another recommendation, scarcely less important in the light of subsequent events, was that it permitted the extension of circuits at all times on the lines already laid down without disadvantage to or modification of those portions already constructed. It laboured at first under this great disadvantage, however, that since in his system every lamp formed an integral part of the circuit the failure of any disabled all and the minor irregularities of operation were cumulative. The solution of this difficulty was found in the cut-out or by-path provided in each lamp, through which the current was automatically shunted in case of failure of the carbons to feed. In this way the integrity of the circuit was maintained independently of the operation of the lamp, and the system has grown until now there is, theoretically, no limit to the number of lamps that can be placed on a circuit, each working independently of all the rest as though it were on an independent circuit. As a matter of fact, the Brush Company have recently constructed a machine intended to supply 125 2,000-c.p. lights from one circuit, and there are many circuits in nightly use upwards of 20 miles in length. The series system, however, is not adapted to the distribution of small currents such as are employed in incandescent lamps. While it has not been approached in its adaptation to the arc lamp, it has made little progress, and that little it has lost, in the incandescent field.

Edison, on the other hand, followed the method of gas and water distribution common in our cities and elsewhere, wherein a constant head or pressure is maintained and the increased demand for energy is supplied by an increase in the flow under the unvarying head. By this method the capacity of the mains must be gauged by the sum of the individual demands; in planning an installation provision must be made for the future, and when that provision is exhausted additional mains must be laid to meet the increased demands. This method had the recommendation of greater flexibility, permitting the supply of all-sized individual demands from the same mains with practically independent circuits for each individual translating device. It had the disadvantage, however, of requiring much larger investments in copper, which increased under some circumstances as the square of the demand in current, and shared with our methods of gas distribution the faults of loss of pressure as the distances increased, especially in cases where the drain upon the mains was large near the source of energy. For this reason the areas that could be supplied from centres of generation were exceedingly limited, though the method was sufficient for the early requirements. As the areas to be covered increased, the ingenious device was resorted to of dividing them up into smaller areas, whose centres were supplied by feeders and mains at the proper potential at their terminals for use throughout the local areas, and thus, and by means of the three-wire system which permitted the distribution of current at double the potential at which it was to be used, the areas that could be economically supplied with current for the incandescent lamp have become comparable to those already covered by water and gas.

But with the advent of the electric railroad new problems were introduced. It was not so much areas as distances that now must be covered, and with the extension of these lines to the suburbs and the growing demand for interurban electric

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lines these problems become more and more urgent of solution in a different and more effective manner than hitherto.

Brush stopped with his discovery of the automatic cut-out for stationary translating devices, and without an equivalent for the moving car the constant-current system lacked sufficient flexibility. On the other hand, with the constant-potential method it was only necessary to double or treble the potential to give equally economical distribution to double and treble the distance. Five hundred volts (about five times that upon which incandescent lamps can be used) was decided upon as within the limits of safety, and has become the standard street railway pressure throughout the country. By this means, with the assistance of feeders, even suburban requirements up to 11 or 12 miles (in one extreme instance) have been supplied, but now come the further requirements of interurban lines, which can only be met by this system by a duplication or multiplication of generating stations, with all that is implied thereby. In these longer distances, the constant-potential method, if it has not already done so, is certainly beginning to trench upon a domain which does not belong to it, as we shall attempt to show.

The problem of distributing current to moving cars by the constant-potential or multiple-arc system is quite different from that of distributing current by the same method to stationary translating devices, in that the position of the load is constantly changing. The cars at times may be all bunched at the further end of the line, and the feeder provision must be sufficient to meet this contingency. If sufficient for this, it involves an investment in copper so much in excess of the mean requirements as to be a heavy burden on the interest charges. Such a heavy burden is this, in fact, that, when the distances exceed eight or ten miles, it is usually deemed more expedient to erect a second station, with all that that implies, than to make use of sufficient copper to overcome the drop that would otherwise result.

It will be evident that in calculating the copper for an installation of this kind, having a constantly varying and shifting load, the best we can do is to proportion it to certain ideal requirements, which may in practice be met only once or twice in the day's run. For all other conditions the amount of copper employed will not be that which will meet the requirements of maximum economy.

In the multiple-arc system it is dangerous to reverse the direction of motion of the motor while the car is rapidly moving, and hence advantage cannot be taken of electrical braking except in cases of emergency. The moving car is always checked by mechanical means, and in descending a grade its energy of position is entirely frittered away in heat on the brake shoe and wheel tyre.

The single trolley is all but universally used, thus making the track and earth a part of the circuit. This introduces an element of uncertainty in the circuit which can never be provided for adequately by the overhead system of feeders and trolley wire, and one which has caused no end of annoyance. When the ground is soaked in water, the resistance of this return is almost negligible ; but when it is dry and parched, or when the track is covered with dry dust or dry snow, it may increase to almost any extent. To obviate these difficulties some companies have actually spent more money in the ground in the attempt to give a uniformly good return to the current than they have spent in their feeders and trolley wire overhead, and yet have failed to obtain an entirely satisfactory result.

Since the electric car has become almost universal in our larger cities a new and equally serious objection to the ground return has developed, in the corrosion of the gas and water pipes and metallic sheathing of cables buried in the ground, due to the electrolysis caused by the large currents. This has been especially noticeable in Boston, Cambridge, and Brooklyn, and no adequate remedy has as yet been devised, nor does there seem at present to be any remedy other than the radical one of abandoning the earth entirely as a return and resorting to the double-trolley system. The question of damages for the destruction of water and other pipes by the return currents from electric railways has not yet come up before the courts, but it would certainly seem that the trolley companies should be held responsible in equity, if not in law. It behoves us, therefore, to look about us for the means of abating that which is not only a nuisance to ourselves, speaking as street-railway men, but an injury to our neighbour, and it is for the purpose of calling attention to a system which appears to meet all the requirements that this paper has been undertaken.

Brush solved the problem of supplying arc lamps arranged in series on a constant-current circuit. He did not go into the street-railway problem on the series method, but his successor, Prof. Sidney Howe Short, made a most determined effort towards its solution and actually constructed and operated for a time two small roads on constant-current circuits. While his plan proved a failure as a practical system, the results obtained were exceedingly instructive, and demonstrated that, if the series system could be made as flexible as the multiple-arc, it would possess many features of economy, both in construction and in operation, to recommend it far above the latter for traction distribution.

In regard to the series system, the following advantages have, I believe, been fully proved, and are admitted by all :

1. The installation of the power station is by far simpler and less expensive than that of a station on the multiple-arc plan.

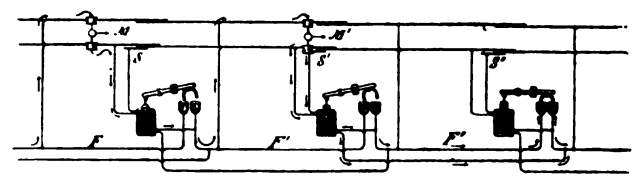
2. Where high potentials are used, as is necessary in long transmissions, both the dynamos and motors are smaller and cheaper to build than those of the same capacity suitable for constant-potential circuits.

3. The amount of copper required for transmissions of equal amounts of power to equal distances is considerably less in the series system, and its weight, having been once determined to best meet the question of economy, continues to meet that question equally well, whether there be one car or many on the line and whether the line be one mile in length or 30. In fact, since the current remains the same, the question to be solved always is merely what size of wire will, all things considered, most economically carry that current, and this will be determined and hold good irrespective of the number of cars, the length of the line, or the position of the cars on the line. In the multiple-arc system (that now in universal use) the same economy could be obtained only by varying the copper with the constantly-changing position and demand of the cars, which is, of course, an impossibility. In the series system it is obtained by simply varying the E.M.F. of the circuit to meet the ever-changing conditions, and this is automatically attended to by the dynamo itself.

4. It is in many respects safer, for, while high potentials are used in the series system, they are confined to the terminals of the dynamos in the power station, and the potentials at the car terminals are only proportional to the work which each car is doing at the time, while in the multiple-arc system the high potentials extend to the terminals of every motor on the line, irrespective of whether it is doing much work or little.

The other advantages will be mentioned at the proper place in the description of the method which follows.

In a system which has been devised recently the main features are that a system of feeders is employed as in the multiple-arc system, which, instead of feeding amperes into the trolley wires, as in the latter, feeds in volts or E.M.F. This may seem to be a rather strange statement to make in regard to a series system, but it will be better understood by reference to Diagram No. 1. F F′ F″ is the main circuit or feeder wire,



normally electrically continuous and independent of the trolley wires above. It is, however, divided into sections, each of which is terminated by a mercury-cup, into which take the copper forks by which these sections are normally connected electrically. The two trolley wires—for this is a double-trolley system—are also divided into similar sections or blocks, the adjacent ends of both wires of adjoining blocks being lapped, but insulated from each other, and the laps are staggered as shown. The further trolley wire of the block is directly connected with one section of the feeder, and the near wire is connected through the coils of an electromagnet with the succeeding sections of the feeders.

Also parallel to the nearer lap, and anticipating it a little, is a short subsidiary wire, S S′ S″, which is connected with a second coil of the same magnet wound parallel with the first, and which in its prolongation short-circuits the mercury-cups of the next succeeding section in advance. The above electromagnets, when excited, raise the forks in the corresponding mercury-cups, breaking the feeder circuit at that point and forcing the current to take another path. As the trolley-wire sections are normally insulated from each other, no current can ever pass through the magnet unless there be a car on that section. The car motor therefore forms the alternative path through which the current has to pass when the fork is raised. In Diagram No. 1 these features are shown, together with cars, M M′, on adjacent trolley blocks. The arrows show the paths pursued by the current, and also how the two cars are thus arranged in series with one another.

It will be noticed that the supplemental conductors and the laps in the trolley wires are so arranged relative to each other that when a car is travelling in the direction of the main current, the trolley travelling upon the wire connected with the fork or switch will contact with the supplemental conductor before reaching the lapping portion of the trolley wires, and the companion trolley will reach its lap after the first trolley has reached its lap and before it has passed beyond the supplemental conductor, while with a car travelling in the opposite direction, the order will be reversed—the trolley upon the wire not connected with the switch first reaching its lap, after which its companion trolley first reaches its lap, and afterward the supplemental conductor. In

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this manner the transition is accomplished in either direction from one section to another, either on the same or another circuit, without spark or interruption of circuit. In fact, there is here accomplished for the series railway car what Brush accomplished for the series arc lamp.

As the number of cars operated on one circuit will be limited by the potential it is deemed safe to have at the dynamo terminals, the road is divided up into as many working sections as may be deemed advisable, each of these sections, one of which may consist of many blocks, being operated on a separate circuit. In this way the potentials may be kept within limits.

It is intended that but one car shall occupy a block at a time. Since the block receives current only while occupied by a car, the entrance of the car on the block may set a signal of danger, which is withdrawn on its leaving that block. If, however, notwithstanding the danger signal, a second car should run on to the block, the two would be thrown into multiple with each other and both brought quickly to rest, thus constituting this system a most perfect block system.

The series car is controlled entirely by shifting the position of the brushes. The current being constant, it is perfectly safe to reverse the position of the brushes, even at full speed. By this operation the motor is converted into a dynamo in series with the one in the power station, and contributes E.M.F. to the line to the last turn of the wheels. Instead of frittering away in heat the energy due to the acquired motion of the car, as in the multiple-arc system, the car is checked by reversing the brushes, and the energy absorbed by thus checking its motion is thrown on to the line for use elsewhere or to the relief of the steam-engine. In descending a grade, too, the energy stored up in the car as potential in ascending that grade is given out to the line as kinetic energy instead of being thrown away as at present. Since in a round trip there is much down grade as up grade, the track is theoretically reduced to a level; and since the car is checked as often as it is accelerated, its motion is theoretically reduced to a continuous and uniform one, and the economies resulting from these ideal conditions are by this system, and by this system alone, theoretically realised. Practically, the economies of operation must be very large, though, of course, far short of the theoretical.

One of the greatest doubts that I have had in regard to this system concerned the ability of the generator to respond promptly to the enormous sudden changes in potential corresponding to the similar changes in current on multiple-arc roads. This doubt has been entirely removed by the experience in a series transmission plant at Geneva which has been in successful operation for nearly two years. Although this plant is driven by water power, the diagrams show that, while instantaneous fluctuations of 1,000 volts were frequent—on several occasions the variation was between 1,400 and 5,800 volts—the regulation was effective and practically instantaneous.

It is believed that this recent improvement renders the series system fully as elastic as the multiple-arc system, and that in view of the difficulties encountered in the latter, the growing tendency to extend electric railroads to greater distances, and especially in view of the recent decision by Judge Greene in the feeder and main patent, awarding the sole right to use feeders to the Edison Company, aside from its own intrinsic merit, this system will soon attract the attention it deserves of the electrical public.

TRADE NOTES AND NOVELTIES.

FIRE EXTINCTION.

It is always advisable for engineers in central electric light stations and in private installations to be prepared in case of an outbreak of fire, and the annexed illustrations show two neat and useful sets of fire-extinguishing appliances, which can be placed in odd corners so as to be ready at hand. Fig. 1 shows an arrangement consisting of four fire-buckets and a portable

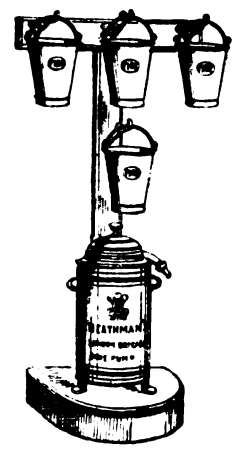

FIG. 1.

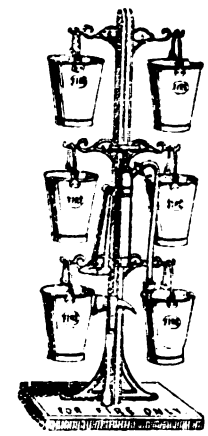

FIG. 2.

hand fire-pump complete upon a stand—the pump will throw a jet 35ft.; and Fig. 2 represents a set of six buckets and a foot bracket fire-pump to work from any bucket, while there is a hatchet available to sever electric casings and wires. Messrs. Heathman and Co., of Endell-street, London, W.C., are the makers.

BRADFORD CORPORATION ELECTRICITY SUPPLY.

Mr. James N. Shoolbred, B.A., M.I.C.E., has communicated to the Society of Arts the following tables in reference to the discussion on Prof. Robinson's paper on "The St. Pancras Electric Lighting Installation," and in continuation of the information in his own paper on "The Bradford Corporation Electricity Supply," read May 4, 1892:

HALF-YEARLY REVENUE ACCOUNT.

Working expenses.	1890. June 30. £ s. d.	1890. Dec. 31. £ s. d.	1891. June 30. £ s. d.	1891. Dec. 31. £ s. d.	1892. June 30. £ s. d.	1892. Dec. 31. £ s. d.	1893. June 30. £ s. d.	1893. Dec. 31. £ s. d.
Salaries and wages..	367 16 8	410 17 10	418 14 3	506 15 4	639 15 10	665 9 11 / 391 8 8	970 4 0	1,136 4 9
Coal	246 17 11	247 0 6	292 18 6	342 7 0	334 2 0	375 16 6	486 0 1	845 0 3
Water	33 16 4	34 0 0	34 15 6	36 19 0	38 12 0	57 7 8	62 4 8	66 9 9
Repairs and miscellaneous	100 11 6	204 13 3	272 7 9	431 1 8	297 8 5	532 4 2	406 10 7	335 7 6
Rent of land	83 18 1	83 18 1	83 18 1	83 18 1	83 18 1	83 18 1	83 18 1	83 18 1
Rates and taxes	46 0 0	104 6 6	67 1 8	69 11 6	112 4 9	101 2 1	133 7 11	145 16 3
Bank interests and commissions	19 1 4	89 14 9	95 9 7	120 7 5	108 2 11	104 1 6	111 1 5	139 11 4
Total working expenses	898 1 10	1,174 10 11	1,261 5 4	1,591 0 0	1,614 4 0	2,311 8 7	2,253 6 9	2,752 7 5
Balance	-39 7 0	377 18 10	832 8 2	2,001 1 0	1,601 12 11	2,386 14 11	2,294 1 6	2,882 7 3
Total gross receipts	£858 14 10	£1,552 9 9	£2,093 13 6	£3,592 1 0	£3,215 16 11	£4,698 3 6	£4,547 8 3	£5,634 14 8
Units sold	39,113	68,794	85,103	154,258	141,622	223,789	207,650	272,964

INTEREST AND SINKING FUND ACCOUNT.

Payments.	1889 Dec. 31. £ s. d.	1890. June 30. £ s. d.	1890. Dec. 31. £ s. d.	1891. June 30. £ s. d.	1891. Dec. 31. £ s. d.	1892. June 30. £ s. d.	1892. Dec. 31. £ s. d.	1893. June 30. £ s. d.	1893. Dec. 31. £ s. d.
Interest on loans.....	467 7 5	360 9 11	360 14 0	409 16 10	545 0 6	636 18 5	719 11 3	771 11 8	785 17 5
Sinking fund	421 13 4	332 10 0	332 10 0	392 16 8	392 16 8	577 7 4	577 7 4	827 19 0	827 19 0
	£889 0 9	£692 19 11	£693 4 8	£862 13 6	£937 17 2	£1,214 5 9	£1,296 18 7	£1,599 10 8	£1,613 16

CAPITAL EXPENDITURE ACCOUNT.

1889. to Dec. 31. £ s. d.	1890 to June 30. £ s. d.	1890 to Dec. 31. £ s. d.	1891 to June 30. £ s. d.	1891 to Dec. 31. £ s. d.	1892 to June 30. £ s. d.	1892 to Dec. 31. £ s. d.	1893 to June 30. £ s. d.	1893 to Dec. 31. £ s. d.
18,456 2 4	25,223 19 11	27,209 4 8	35,370 7 11	40,224 19 10	45,136 8 6	48,568 12 11	52,309 2 4	56,691 1 2

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	Profit and Loss Account.	£	s.	d.
1889.	Dec. 31.—To debit of revenue	1,079	8	5
1890.	June 30.—To loss on half-year	732	6	11
	Dec. 31.— ,, ,,	315	6	0
1891.	June 30. ,, ,,	30	5	4
	By balance	290	11	7½
		£2,447	18	3½
		£	s.	d.
1891.	Dec. 31.—By profit on half-year	971	4	10
1892.	June 30.— ,, ,,	387	7	2
	Dec. 31.— ,, ,,	1,089	6	3½
		£2,447	18	3½
1893.	By balance from 1892	290	11	7½
1893.	June 30.—By profit on half-year	625	16	10½
	Dec. 31.— ,, ,,	1,179	1	0

Rates per Unit.

—	1890.	1891.	1892.	1893.
	s. d.	s. d.	s. d.	s. d.
Price charged per unit sold	0 5	0 6	0 5	0 5
Working cost ,, ,,	0 4·6	0 2·8	0 2·6	0 2·5
Capital expended ,, ,,	3 5	3 4	2 8	2 4

In an analysis (given by Mr. Crompton in *Lightning*, January 4, 1894) of the cost of supplying electricity in England in 1892, he finds that at 12 central working stations with "continuous" currents, the average capital expended per unit sold was 5s. 1½d.; while at the nine stations working with "alternating" currents, the average was 8s. 8d.

PHYSICAL SOCIETY.

At a meeting of this society, on the 9th inst., Prof. A. W. Rücker, F.R.S., president, in the chair, **Prof. S. Henrici, F.R.S.**, made a communication on "**Mathematical Calculating Machines, Especially a New Harmonic Analyser.**" After mentioning the general principles on which such machines are based, the author showed a new arithmometer devised by Prof. Selling, in which the jerky motions of the numeral wheels common in such instruments are eliminated, and the operations simplified. Another arithmometer of very compact design, named the "Brumviga," had been placed on the table by Prof. Boys. The simple and ingenious "Hatchet" integrator was then shown. It resembles a small hatchet, with a tracing-point projecting at right angles to and at the end of the handle. Moving the point from near the centre of mass of any closed curve, round the curve once and back to the starting point, the distance between the initial and final positions of the hatchet head is a measure of the area of the curve. The instrument has been found very useful for indicator diagrams. A Hine and Robertson's planimeter, lent by Prof. Perry, an Amsler planimeter combined with a pentagraph for measuring small areas, an Amsler integrator to give areas and first moments, and a beautiful sphere and cylinder rolling integrator of great accuracy by Coradi of Zürich, were shown, as well as an ingenious integraph devised by Abdank Abakonowitcz. Passing on to harmonic analysers, Prof. Henrici explained the object of such instruments—viz., to determine the coefficients in Fourier's expansion for any periodic curve :

$$y = A + A_1 \cos\theta + A_2 \cos 2\theta + \ . \ . \ + B_1 \sin\theta + B_2 \sin 2\theta + \ . \ .$$

and briefly described Lord Kelvin's instrument now in use at the Meteorological Office. This machine gives the first term and three pairs of coefficients, A and B, but is large and expensive. The author had endeavoured to devise a simple and more portable instrument, and now described the various stages in the evolution of his new analyser. Using Clifford's method of wrapping the curve round a cylinder, he saw that by imparting a simple harmonic motion to a plane tangential to the cylinder, which plane carried an Amsler planimeter whose tracing-point followed the intersection of the plane with the curve as the cylinder rotated, any coefficient, A*n* or B*n*, could be determined. This arrangement had considerable friction, and only gave one coefficient at a time. It also necessitated readjustment of the period of the harmonic motion for each pair of terms. Another machine, founded on integration by parts, was then constructed, in which the relative periods of cylinder and registering wheels was adjusted by a disc and roller, the motion being transmitted to the wheels by bands driven from the disc spindle. This gave A*n* and B*n* at one operation. Mr. A. Sharp used this machine for some time, and then designed an inversion of it, in which the curve was laid out flat and the machine rolled over it. This arrangement greatly facilitated the multiplication of registering wheels, and enabled several pairs of coefficients to be determined at once. The first machine of this kind showed several small errors, which were avoided in a second instrument, a specimen of which, made by Coradi, was exhibited and described. A rectangular frame, carried on three rollers (two being fixed to the ends of a long axis), traverses the paper in the direction of y, and the tracing-point is fixed to a carriage which moves on the frame in a direction perpendicular to y—*i.e.*, in the direction of θ. A band is attached to this carriage and imparts a motion proportional to θ to two horizontal areas (one for the A coefficients and one for the B's), placed above and parallel to the long roller axis above mentioned. Each of the two axes carries five pinions having teeth in the ratios 1, 2, 3, 4, 5 respectively, which gear with crown wheels fixed to vertical spindles. The latter, therefore, rotate through angles proportional to θ, 2θ, 3θ, 4θ, and 5θ. To the lower ends of these spindles horizontal rings are attached, in which the bearings of a registering wheel are formed. Each wheel rests on a cylinder carried by the long axis, and rolls or slides thereon according as its axis is parallel or perpendicular to that of the cylinder. Moving the tracing-point once round the curve gives five pairs of coefficients. By changing the driving band to other pulleys, so as to turn the pinions at different rates relative to the θ movement, the sixth, eighth, tenth, and seventh and ninth pairs can be obtained. The chief drawback of the instrument is that the registering wheels are not easy to read, whilst the backlash of the crown wheels and pinions introduces small errors. In the latest form of instrument toothed wheels are dispensed with, and glass spheres carried in frames on the vertical spindles roll on the horizontal cylinders. Each sphere actuates two registering wheels on fixed axes at right angles to each other, and these give respectively the sine and cosine coefficients. The number of vertical spindles is therefore halved, and the instrument greatly simplified. These details have been introduced by Coradi. A working drawing of another analyser designed by Mr. Sharp, which gives the amplitude and epoch of the curve resulting from each pair of terms in Fourier's expansion, was exhibited. The discussion on Prof. Henrici's communication was postponed until next meeting.

Mr. H. Wilde, F.R.S., then exhibited and described his "**Magnetarium.**" This consists of a hollow geographical globe wound all over the inner surface with insulated wire in planes parallel to the equator. Within this globe is a sphere wound with wire on its surface, and having its axis inclined at 23½deg. to that of the outer globe. By means of epicyclic gearing the spheres can be made to rotate at slightly different rates. When electric currents of suitable strength are passed through the two windings, the magnetic condition of the earth can be imitated, both as regards distribution at any epoch and the secular variations. A better result was obtained by putting sheet iron over the land areas, and a still closer approximation by using thin iron over the water areas. A magnetic chart and tables giving the magnetic elements at various places for different epochs were shown. The author mentioned that recent observations by the United States Survey at Ascension Island, and by Prof. Thorpe in Senegambia, had confirmed results obtained by the magnetarium. The **President** said he had tried the apparatus, and found the Siberian oval closely imitated. The secular variations at Greenwich were also well shown. In South America the approximation was not so good. In reply to a question by Mr. Blakesley, **Mr. Wilde** said the present position of the pole of the inner sphere was 84deg. west, 67deg. north.

COMPANIES' MEETINGS.

CAMBRIDGE ELECTRIC LIGHT SUPPLY COMPANY, LIMITED.

The annual meeting of this Company was held last week at the Company's offices, 2, Sidney-street, the Rev. G. B. Finch, chairman, presiding.

The report of the directors was as follows :

"Your directors have pleasure in reporting that the prospects of the Company are satisfactory. During the last six months lamps equivalent to about 6,000 lamps of 10 c.p. have been connected to the Company's mains, making a total at the present time equal to 8,000 lamps of 10 c.p., and there is every prospect that the number will be largely increased during the present year. The plant during the last three months has been fairly loaded, and has worked to the satisfaction of the directors; but, owing to the coal strike in the autumn, a considerably increased price had to be paid for fuel. It seemed to your directors that it would be inexpedient to commence a profit and loss account, in respect of supply of energy, with only a small portion of the machinery at work, and they have therefore deemed it advisable to carry all receipts and expenditure under this head up to June 30 last to capital account. The Company has made a profit of £268 to December 31 last, and it is anticipated that with the additional lamps lately connected and those which will shortly be connected, your directors will be able at the next annual meeting to advise the payment of a substantial dividend for the current year. Your directors have thought it necessary to apply to the Local Authority for their sanction to the temporary suspension of the supply of current, between the hours of 2 a.m. and 5 p.m. in summer, and 2 a.m. and 6 a.m. in winter. A supply during these hours will involve the shareholders in heavy additional expenditure at the present early stage of the Company's operations, without any corresponding benefit to the general public. Your directors, however, hope that the applications for current will shortly be sufficient to justify them in making the supply continuous, and it will be their endeavour to effect this at the earliest opportunity. The Rev. G. B. Finch and Mr. J. Simpson retire by rotation; the latter is eligible and offers himself for re-election. The directors also recommend the election of Dr. P. W. Latham and Mr. W. C. Hall."

The **Chairman**, in moving that the report and accounts be

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received and adopted, stated that he thought they might say that the anticipations which they all had at the outset had been even more than realised by the success of the Company. The statement in the second paragraph of the report was certainly very satisfactory to the town. They had had applications for many more lamps, and the work of extension showed no signs of being arrested. The colleges were beginning to take the light for the rooms of the undergraduates. That had been going on for some little time, and when once that was established they expected they would find some of their best customers amongst the residents in the rooms of the colleges, and that they would get a very good return from the lamps in the students' rooms. There was a feature in the report which they ought not to pass over, and that was with regard to carrying all receipts and expenditure under the head of profit and loss up to June 30 to capital account. The directors thought it would be much better to treat all receipts and expenditure as belonging to the capital account up to a certain date. They hoped that the shareholders would agree with the course adopted. Alluding to the sixth paragraph in the report, the Chairman said they all knew that in the summer months they could not carry on the concern so as to make a profit at the present time, and that was the experience of all companies at the beginning. During the summer months at Newcastle the losses had been gradually dwindling down, until at last there was no loss whatever. They were so situated that they made a profit all the year round. They anticipated, after a little time, that that would be the case in Cambridge. At Newcastle 5½ per cent. was paid, and the Newcastle company was established two or three years before the Cambridge Company. From October 1 to February 20 last the Company made a profit of £768. The coal strike imposed a burden of £50 a month upon them which otherwise they would not have had. If it had not been for the coal strike they would have had a profit of £918 in the five months. He thought that that justified the statement made at the commencement of the report that the prospects of the Company were satisfactory. The shareholders would notice the following item in the balance-sheet, "Debentures, £7,000 at 5 per cent."; £7,000 was a sum borrowed from Fosters' bank, and they held a charge over the Company's property. It was called a "debenture," but that was a misprint; it should have been described as a debt owing to Fosters. What the directors desired to do now was to raise a sum not exceeding £10,000 on debentures of 4½ per cent., and offer the debentures to the members of the Company in the first instance on terms to be afterwards appointed. They did not entertain any doubt of their ability to raise the money, but they hoped it would come from the shareholders in preference to any persons outside. Probably they would be offered *pro rata*, but inasmuch as some might not be expected to take up their proportion, the shareholders would be asked to signify how much they would be willing to take. Referring to the last paragraph of the report, the Chairman said he did not offer himself for re-election as a director; Mr. Simpson did, and he (the Chairman) hoped he would be reappointed. As regarded himself, he felt very great regret at retiring, but he did so for the same reason that induced him to retire from the Town Council. One regret certainly it was that he would not any longer transact business with persons whom he found it so pleasant to meet under all circumstances. That would be his chief regret in the matter.

Sir Benjamin Browne seconded the adoption of the report.

The **Hon. C. A. Parsons**, in answer to several questions put by Mr. Young, explained that the expenditure had been kept down to the very lowest figure. A large number of new lamps were coming on, and they hoped to run during next summer without any loss at all in the working expenses. They had laid 18½ miles of single cable, and 5½ miles of piping, which was exactly the same amount laid at Scarborough, and the total expense was within £200 of each other. The works had been carefully carried out in both places. At Newcastle they had about six miles of piping, but they had about 28 miles of cable, and there they supplied over 18,000 lamps at the present time. The cost of the Cambridge station had been a little more than the Newcastle station, the difference arising chiefly in the building, and in a larger expenditure on provisional orders and preliminary expenses. At Newcastle they saved a great deal in building; they took old buildings already there.

The report was then put to the meeting and adopted.

Mr. Matthew proposed the appointment of Mr. J. B. Simpson, Dr. P. W. Latham, and Mr. W. C. Hall as directors.

The proposition was seconded by **Mr. Barrett**, and agreed to.

On the motion of **Mr. Bowes**, Mr. Arthur Rutter was re-elected auditor.

Sir Benjamin Browne said that the question of the remuneration of directors was considered at the last meeting, and it was decided that it had better stand over for a year. He proposed that the sum of 150 guineas be set aside as remuneration for the board of directors of the Company up to the present time. The motion was seconded and carried.

BIRMINGHAM ELECTRIC SUPPLY COMPANY, LIMITED.

The ordinary general meeting of this Company was held last week at the offices, Dale End, Mr. Henry Buckley, presiding.

The **Chairman**, in moving the adoption of the report and statement of accounts, which were published in our last issue, stated that the Company, like most others, had suffered from the coal strike. It was only fair to assume that in a time of general commercial depression shopkeepers and others were not so willing to incur capital expenditure in lighting alterations if they could avoid it. However, shareholders might take hope from the latest Board of Trade returns that brighter days were opening, and the Company, no doubt, would share in any improvement in business. But notwithstanding the past depression, the Company during the past year had made satisfactory progress, although there had been phenomenally clear days through the winter months. At the end of 1892 the Company had an equivalent to 8,329 16-c.p. lamps. At the end of 1893 the number was 10,223, and there had since been a further increase of 1,000. The consumers in the same time had increased from 223 to upwards of 300, and the current, measured by units, had increased from 214,088 to 352,096. The percentage of increase had been—in lamps 22·7, in consumers 30·3, and in current 64·5. The sum placed to reserve accounts compared most favourably with other companies. The directors were doing well to deal liberally under that head. Last year he referred to the question of new areas—Edgbaston, the residential section, and the jewellers' quarters. The question at that time was deferred in deference to the City Council. At their July meeting the matter was brought up, and the scheme was practically approved, with the exception of certain clauses, which were to be discussed between the Company and the Council committee. It was now hoped that if there was no dissolution the Company would be armed with the necessary parliamentary powers, and be then in possession of the areas, which he felt sure would prove beneficial to the Company.

Mr. C. A. Harrison seconded the motion, which was agreed to.

The retiring directors and auditors were re-elected, and the proceedings closed with a vote of thanks to the directors.

HOVE ELECTRIC LIGHTING COMPANY, LIMITED.

The second annual general meeting of this Company was held on Wednesday at Hove, Colonel H. Woods, C.B., the vice-chairman of the Board of Directors, presiding.

The **Chairman**, in moving the adoption of the report and accounts, which were given in our last issue, congratulated the shareholders on the continued satisfactory progress of the Company. As they would have seen from the report, the number of lights connected continued to increase, and it was expected that before the end of the current year the number of lights would be more than double the number on December 31 last, and that they would then have 14,000 or 15,000 connected up. The exact number now was 12,600. When it was considered that the actual expenditure of the Company would probably at that time not exceed £35,000 or £40,000, it must, he thought, be admitted that, compared with what was done by many other companies, this was extremely satisfactory. In addition to the private lights, it was hoped that before the end of the year the Hove Commissioners would put up some public lamps along the front, if not in some of the streets, and this would add materially to the business of the Company, and be an advantage to the public in Hove. The success of the Company was far in excess of what was anticipated, and the shares were consequently a good investment. But to ensure the continued success of the Company, and to enable them to meet the calls upon them by intending consumers, further capital was required. Hitherto their contractors, Messrs. Crompton and Co., had promptly executed all orders, and had met the directors in every way, but considerable extension was necessary on such a scale that it would not be prudent for the directors to enter into any fresh contracts unless further capital was subscribed. There was another matter upon which the directors were able to congratulate the shareholders—the retirement of the opposition company from the field, thus giving this Company the monopoly. The competition between the two companies had been both fair and straightforward, and now that the other company were retiring from the field they were advising their customers to come over to the underground system. Though they sympathised with the shareholders in the other company, they anticipated that the result of its withdrawal from the field would be that the Hove Electric Light Company would do more business. Dealing with the present condition of affairs, he said the directors proposed to offer the balance of the shares to the public, and at the same time issue a debenture prospectus. The shareholders would be asked to empower the directors to issue more debentures than by the articles of association they had now the power to do; but it was not intended to make a higher issue than £12,500 for the present, though it was proposed that this sum should form part of a total of £25,000 when the magnitude of the works justified the directors in making such an issue. He concluded by proposing the adoption of the report.

Mr. C. F. Tufnell seconded the motion for the adoption of the report and accounts, and the resolution was carried.

Colonel A. J. Filgate, R.E., and Colonel H. Wood, C.B., the retiring directors, were re-elected on the motion of **Mr. Tufnell**, seconded by **Mr. Albright**, the latter complimenting the directors on the manner in which they did their work.

Mr. Robert Payne, F.C.A., was reappointed auditor to the Company.

The **Chairman** then proposed: "That the directors be and they are hereby empowered to borrow or raise any sum or sums of money on such security and upon such terms as to interest or otherwise as they may deem fit, and for the purposes of securing the same and interest or for any other purpose may create, issue, make, and give respectively perpetual or redeemable debentures or debenture stock, or any mortgage or charge upon the undertaking or the whole or any part of the property, present or future or uncalled capital of the Company, provided that they shall not without the further sanction of a general meeting of the Company borrow or raise any sum of money exceeding in the whole £25,000."

Mr. Tufnell seconded, and the motion was agreed to.

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COMPANIES' REPORTS.

W. T. HENLEY'S TELEGRAPH WORKS COMPANY.

Report of the directors to be presented to the shareholders at the ordinary general meeting, to be held at the Company's offices on Thursday, March 22, at 2.30 p.m.

The directors have pleasure in submitting their annual report. The annexed accounts show that a net profit has been made of £10,777. 6s. 2d. After payment of interest and income tax, and making allowance for depreciation of plant, there remains £7,256. 14s. 1d., to which must be added £13,399 10s. 1d. brought from last year. Deducting £1,050, the half-year's dividend on preference shares paid in October last, there remains a disposal balance of £19,606. 4s. 2d. The directors have added £10,000 to the reserve fund, and they propose the payment of a further half-year's dividend on the preference shares at the rate of 7 per cent. per annum, and a dividend for the year at the rate of 5 per cent. free of income tax on the ordinary shares; these payments together absorb £4,468. 10s., and leave a balance of £5,137. 14s. 2d. to be carried forward. A further sum of £4,000 has been paid off the £30,000 B debentures created in 1891, which has reduced their amount to £12,000. The improvements and extension of the Company's factories at North Woolwich, which were contemplated when the preference capital was subscribed, have been completed, and the buildings, machinery, tools, etc., of the Company are now in first-class condition. The general business of the Company has been satisfactory, and a few hundreds of miles of submarine cables have been manufactured for various telegraph companies, and for the British Government. The directors who retire on this occasion, in accordance with the provisions of the articles of association, are Mr. Frederick Newton and General George Hutchinson, C.B., C.S.I., and, being eligible, they offer themselves for re-election. The meeting will appoint auditors for the ensuing year.

PROFIT AND LOSS ACCOUNT, YEAR ENDING DEC. 31, 1893.

Cr.	£	s.	d.
Directors' remuneration, salaries, rent of offices, maintenance of works, general expenses, etc ...	9,301	1	5
Bad debts	598	8	1
Balance, being profit for the year carried down ...	10,777	6	2
	£20,676	15	8
Interest on mortgage and debentures	1,997	7	6
Income tax	523	4	7
Amount written off for depreciation of plant	1,000	0	0
Addition to reserve account	10,000	0	0
Half-year's dividend at rate of 7 per cent. per annum on preference shares, paid in Oct., 1893... £1,050 0 0			
Proposed half-year's dividend on ditto at 7 per cent. per annum... 1,050 0 0			
Proposed 5 per cent. dividend on the ordinary shares ... 3,418 10 0			
	5,518	10	0
Balance carried forward to 1894	5,137	14	2
	£24,176	16	3

Cr.	£	s.	d.
Gross profit on trading, including rents of cottages, etc.	20,676	15	8
	£20,676	15	8
Balance brought down	10,777	6	2
Amount brought forward from 1892	13,399	10	1
	£24,176	16	3

BALANCE-SHEET, DEC. 31, 1893.

Dr. Liabilities.	£	s.	d.
Authorised share capital—7,000 ordinary shares of £10 each	70,000	0	0
3,000 preference shares of £10 each	30,000	0	0
	£100,000	0	0
Share capital issued—6,837 ordinary shares, £10 each ... £68,370 0 0			
3,000 preference shares, £10 each... 30,000 0 0			
	98,370	0	0
Mortgage and debentures	37,000	0	0
Creditors on trade accounts ... 21,644 10 0			
Unclaimed dividends ... 45 0 0			
	21,689	10	0
Reserve accounts—reserve against investments, etc. 46,019 10 10			
Reserve under cable repairing contract ... 1,723 17 2			
	47,743	8	0
Profit and loss—amount to be appropriated to dividends—on ordinary shares at 5 per cent... 3,418 10 0			
On preference shares at 7 per cent. 1,050 0 0			
4,468 10 0			
Balance to be carried forward... 5,137 14 2			
	9,606	4	2
	£214,409	2	2

Cr. Assets.	£	s.	d.
Property consisting of freehold land, buildings, machinery, plant, and goodwill	102,769	12	0
Debentures and shares held in other companies ... £52,917 7 3			
Ordinary shares held by the Company ... 1,000 0 0			
	53,917	7	3
Stock-in-trade, including expenditure on orders in hand	34,612	14	6
Debtors after making provision for bad and doubtful debts	18,758	6	9
Bills receivable in hand	1,818	2	8
Cash at bankers and in hand	2,532	19	0
	£214,409	2	2

BUSINESS NOTES.

Western and Brazilian Telegraph Company.—The receipts for the week ended March 9 were £3,252.

Liverpool Overhead Railway.—The traffic receipts of this railway for the week ending 11th inst. amounted to £687.

Fire.—A fire has occurred at the Hope Jones Electric Organ Works, Birkenhead. Damage to the extent of about £1,000 was done.

Sale of Cadby Hall.—Cadby Hall, the premises of Woodhouse and Rawson, Limited, at Kensington, will be put up to auction by Messrs. G. A. Wilkinson and Son next month.

The Tenders for Edinburgh.—To-morrow (Saturday) is the last day for receiving tenders required by the Corporation of Edinburgh for work in connection with electric lighting.

Dorset.—At a meeting of the County Council it was reported that the new asylum was rapidly approaching completion. The contract for electric lighting has been 1st to Mr. F. M. Newton, of Taunton.

Tender Accepted.—The tender of Messrs. Penman and Co., of Glasgow, has been accepted for the supply of a Cornish boiler for the electric light station, Abercorn Basin, for the Belfast Harbour Commissioners.

Harrogate.—The town clerk has been instructed to confer with Mr. Wilkinson, the electrical engineer, and have the agreement for carrying out the contract prepared and submitted to the General Purposes Committee.

Oriental Telephone Company.—The Oriental Telephone and Electric Company confirmed on Monday the resolutions passed at a meeting last month, directing the winding up of the Company for the purpose of reconstruction.

Stock Exchange Quotation.—An application has been made to the Stock Exchange Committee to appoint a special settling day in, and to grant a quotation to, the City of London Electric Lighting Company, Limited, for their £100,000 5 per cent. redeemable debenture stock.

Lifting Machinery.—Messrs. Barry and Higham, of Broad-street House, Old Broad-street, E.C., inform us that they have been appointed London agents for the crane and various lifting machinery manufactured by Mr. Thomas Smith, of Steam Crane Works, Rodley, near Leeds.

Electric Lighting of Tramcars.—As stated in our last issue, the general manager of the Glasgow Corporation Tramways invites tenders for the electric lighting of about 240 tramcars for one or more years. Communications to be sent to Mr. John Young, City Chambers, Glasgow.

Cheltenham.—The Electric Lighting Committee of the Town Council has been remodelled as follows: Aldermen Captain Griffith, Colonel Thoyts, and G. Norman, and Councillors King, Lawrence, Parsonage, Ward-Humphreys, and Woodard, the Mayor being an ex-officio member.

Tenders for Sutton.—The Sutton (Surrey) Local Board invite, by April 4, tenders for the purchase of the powers granted to them by the Board of Trade under the Sutton (Surrey) Electric Lighting Order. Further particulars can be obtained of the Board's surveyor, Mr. A. D. Greatorex, C.E.

City and South London Railway.—The receipts of the Company for the week ending March 11 were £930, against £859 for the same period last year, or an increase of £71. The total receipts for the first half-year of 1894 show a decrease of £58 compared with those for the corresponding period of 1893.

The Manchester Athenæum.—The Manchester Athenæum authorities are considering the question of lighting the building by electricity, and they have instructed Mr. Clirehugh, of Messrs. Wilson and Clirehugh, Temple-chambers, Brazenose-street, Manchester, to prepare plans and specifications for carrying out the work.

Malton.—A number of people gathered together last week to witness the reinstallation of the electric light at the works of the Malton Farmers' Manure and Trading Company, Limited, which were partly destroyed by fire three months ago. The electric light installation has again been put in by Messrs. Parr and Gillies, of Haggerston.

Eastern Telegraph Company.—The directors announce the payment on April 13 of interest of 3s. per share, less income tax, being at the rate of 6 per cent. per annum on the preference shares for the quarter ended March 31, and the usual interim dividend of

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2s. 6d. per share on the ordinary shares, tax free, for the quarter ended December 31.

Leeds.—The Buildings Sub-Committee of the Town Council have had presented to them by the chairman a report on the cost of supplying the electric light from their own installation, and as to whether it was advisable to transfer the lighting to the Yorkshire House-to-House Electricity Company. The matter has been deferred for a month.

Lighting of Pumping Stations.—At the annual meeting of the General Hydraulic Power Company, Limited, Mr. H. Chapman said, with regard to providing the electric light, that the directors had decided in the first place to light up the City-road pumping station, and he believed they would thus be able to supply the light with advantage to the consumer.

Shop-Lighting.—A number of shops in Aberdeen has been fitted up with the electric light. In nine of these cases, the installation has been carried out by Messrs. New and Mayne, electrical and general engineers, under the personal superintendence of Mr. P. C. Middleton, their resident engineer. Messrs. New and Mayne have ready for lighting a further 22 shops.

Indian Agency.—Mr. Archibald A. Crawford, A.M.I.E.E., of Elphinstone Circle, Bombay, announces that he has been appointed general agent for India for the Allgemeine Elektricitäts Gesellschaft, of Berlin. At the same time he states that this enterprise will not interfere with his business in the many special fittings and other articles imported by him up to the present.

Commercial Cable Company.—The report for the year 1893 shows that the gross receipts were 1,842,346dol., the working expenses 784,600dol, and the net income 1,057,746dol. Dividends were paid at the rate of 7 per cent. per annum in respect of the year, absorbing 613,376dol., and of the remaining 444,370dol. the sum of 389,600dol. was applied in January last to the repayment of the remainder of the debenture bonds.

Islington.—The Clerk to the Islington Vestry mentioned at a meeting last week that he had been informed by Mr. Lewis, the solicitor, that the provisional contract with the Great Northern Railway Company had now been settled, and he asked the Vestry to advance £850 deposit money for the site for an electric lighting station. The request was referred to the Finance Committee, and it was agreed that the seal of the Vestry be attached to the provisional agreement.

Tenders for Boilers.—Tenders are required for the manufacture and delivery at their Neepsend works of three Lancashire steel boilers, each 30ft. long by 7ft. 6in diameter, for the Sheffield United Gaslight Company, Neepsend Station. Copy of the drawing and specification, with form of tender, may be obtained on application to the engineer, Mr. Fletcher W. Stevenson, on payment of 10s. 6d. Tenders to Mr. Hanbury Thomas, general manager, Commercial-street, Sheffield, at the company's offices, by 31st inst.

Direct Spanish Telegraph Company.—The report of the directors for the half-year ended December 31 states that the accounts, after providing for debenture interest, show a balance to the credit of profit and loss of £4,996. After adding the usual sum of £2,500 to the reserve fund, the balance of profit and loss amounted to £2,496, out of which a dividend at the rate of 10 per cent. per annum on the preference shares, and a dividend at the rate of 4 per cent. per annum, free of income tax, on the ordinary shares, is recommended.

Burton.—At a meeting of the Town Council last week Alderman Lowe moved the adoption of the report of the Gas and Electric Lighting Committee. He said that the introduction of the electric light in the town was a great success ; the only regret experienced about the scheme was that the customers were not numerous. The committee, however, felt sure that when the satisfactory nature of the new illuminant became generally known there would be a great influx of applications for its use. Councillor Turner seconded the motion, which was passed.

Appointment Open.—The Corporation of Belfast invite applications for the post of resident engineer for central electric lighting station from gentlemen who have had a thoroughly practical training both as mechanical and electrical engineers. Candidates should have had practical experience in central-station work, and also, if possible, in the laying of electric light mains. The salary will be £250 per annum. A schedule of duties will be sent by the town clerk on application. All applications should be in the hands of Sir Samuel Black, town clerk, by 20th inst.

Canterbury.—The following report of the Electric Light Committee of March 1 was submitted to a meeting of the Town Council last week: "A letter was read from the Brush Electrical Engineering Company, asking the Corporation to give them an extension of time for forming the Canterbury Electricity Supply Company. The committee recommend that an extension be granted until June 30, 1894, and that a letter be written expressing a hope that the company intend shortly to issue a prospectus, as until that is done the whole matter is at a standstill." The report was adopted.

Portsmouth.—The Electric Lighting Committee last week submitted to the Town Council certificates from Messrs. Waller and Manville for payment to the contractor for building (Contract No. 1), of the sum of £250, and to the contractors for boilers, engines, and electrical plant (Contract No. 2), of the sum of £1,350, and to the contractors for conduits, etc. (Contract No. 3), of the sum of £2,587, and recommended that such amounts be paid. The committee further recommended that they be authorised to appoint such officers and workmen as are found to be required in connection with the electric lighting in the borough. The report was adopted.

Mill-Lighting.—Messrs. Bennett and Druce, Preston, have received instructions from Messrs. Horrockses, Crewdson, and Co., Limited, the well-known cotton spinners, to instal a complete system of electric light in the new mill in course of erection. The plant will consist of three 500-light dynamos—two of which will be driven by the main engine, and a third off a special vertical engine. An interchangeable system of wiring has been devised by Mr. Druce, of this firm, so that complete failure of the light will be an impossibility. About 900 lamps will be installed in the mill, and the whole promises to be one of the largest and most complete mill installations in Lancashire.

Brighton.—The accounts of the electric lighting department for 1893 were submitted at the last meeting of the Town Council. Alderman Moon said the amount carried to the net revenue account was £4,011, out of which there had to be paid as interest on redeemable stock £2,058, and the amount transferred to loans fund and accrued due to date was £1,653 ; leaving a balance of £300 to be carried to net revenue. This, as a result of the second whole year's working, was not unsatisfactory. The number of houses connected with the system in 1892 was 215, and that figure had since been nearly doubled—being now 423. The total number of units sold in 1892 was 156,048 ; and in 1893, 286 895.

Shirley and Freemantle.—At the last meeting of the Local Board of Health, the Chairman proposed that the question of lighting the district with electricity be referred to the General Purposes Committee for consideration, and to report on the most economical means of doing the same. He said he did not think that they would have to pay more, and he thought there might be a considerable reduction in the cost of lighting in the district by electricity instead of gas. Mr. Ollis seconded the proposition, stating that it was thought sufficient water power could be obtained to give the motive power necessary to obtain the electric light, and then it could be got at the cheapest possible cost. The proposition was unanimously adopted.

Acton.—The Chairman of the Local Board stated at a meeting last week that he had been asked by a local paper to say something as to what the Board were doing in the matter of the lighting of the district by electricity. The Board were about to enter into an agreement with a Mr. Medhurst on the subject, and under that agreement the streets of the district would be lighted by electric light at the same rate as the Board were now paying for gas lighting. He did not think the Press could ask the Board to say more than that at the present moment. What he had said showed that the Board were doing something, and it was likely the agreement he had alluded to would be entered into, and, if so, would be carried out within the present year.

Elmore's German Company.—An extraordinary general meeting of Elmore's German and Austro-Hungarian Metal Company, Limited, was held on Monday at Winchester House for the purpose of passing resolutions to the effect that the second special resolution passed in June, 1892, be rescinded, and that the new shares authorised to be created by the first special resolution passed at that time, and the 25,000 shares now unissued of the original capital of the Company, should be called preference shares. After some discussion the resolutions were passed conditionally, the directors agreeing not to carry them into effect if an alternative scheme which was presented (having been prepared by Mr. Elmore) could possibly be carried out.

Edison and Swan United.—The directors of the Edison and Swan United Electric Light Company, Limited, have resolved to recommend a payment on account of the dividend of the current year at the rate of 5 per cent. per annum, less income tax, on the A shares of the Company, for the half-year ended December 31, 1893. This will work out as follows: On the 89,261 ordinary shares, £3 paid, 1s. 6d. per share ; on the 5,000 shares, £5 paid, allotted to the Edison Electric Light Company, Limited, 2s. 6d. per share ; on the 12,139 shares £5 paid, allotted to the Swan United Electric Light Company, Limited, 2s. 6d. per share. The payment will be made upon the register as it stood on the 13th inst., and the dividend warrants will be issued on the 20th inst.

Willans and Robinson, Limited.—This Company has been registered with a capital of £300,000, divided into 30,000 £6 per cent. cumulative preference and 30,000 ordinary shares of £5 each. The object is to acquire the business of Messrs Willans and Robinson, Limited, carried on at Thames Ditton, Surrey, and to carry on the business of mechanical and electrical engineers. The first signatories, with one share each, are: Mark H. Robinson, Chatley, Fassett-road, Surbiton ; Sir Gilbert Clayton-East, Hall-place, Maidenhead ; Captain M. Riall Sankey, Arterberry-road, Wimbledon ; George W. Anderson, Fenwick-chambers, Liverpool ; Thomas O. Lazenby, Tiverton, Devon ; Percy A. Low, Maybury Lodge, Thames Ditton ; and J. E. Thore, Red Cottage, Thames Ditton.

Blackpool.—Messrs. John Fowler and Co , Leeds, have obtained the contract for the extension of the Blackpool Electricity Works. Two new tramcars are to be procured, either with separate motor trucks or on the bogie principle, and the open cars, which have not been a success on the line even during the summer, are to be disposed of. In the meantime, Mr. M. Holroyd Smith is directing the preparations for putting the tram line in complete repair preparatory to running it by electricity again. The eldest son of Mr. Ralph Rushton has gone into the office of Mr. R. Hammond preparatory to entering upon a course of training at Faraday House. The Free Methodist chapel in Adelaide-street will be closed for alterations after Easter Sunday ; the electric light is to be installed.

Bristol.—The Electrical Committee held their fortnightly meeting on Friday. The committee considered the desirability of

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reducing the charge for current consumed in the daytime, and determined to reduce the price for current supplied between midnight and one hour before sunset to 4d. per unit. The current consumed under this arrangement will be ascertained by means of meters. The committee also determined to allow discounts off the quarterly accounts for current consumed after the 31st inst. on the following basis: on accounts of £50 per annum, 5 per cent; £100 per annum, 10 per cent.; £250 per annum, 15 per cent.; £500 and over per annum, 20 per cent. The secretary presented the statement of accounts required by the Electric Lighting Act to December 31, 1893, in the form prescribed by the Board of Trade.

R. Bolton and Co., Limited.—Under a winding-up order made last January against R. Bolton and Co., Limited, accounts have been issued showing total liabilities £2,259, a deficiency of £1,248 as regards creditors, and a total deficiency of £8,248 to the shareholders. The Company was formed in April, 1893, to purchase for £8,000 the business of a merchant, engineer, etc., previously carried on by Mr. Reginald Bolton. The nominal capital was £12,000, but no prospectus was issued. The causes for the failure are stated to be depression in business, owing to the low state of the Italian and Sicilian markets, where the chief business of the company was transacted, bad debts, and depreciation in value of a large stock of carbons. The creditors and shareholders met on Wednesday and elected the official receiver as liquidator to wind up the Company, with a committee of inspection.

A Question of Vibration.—On Tuesday and Wednesday, in the Chancery Division of the High Court of Justice, Mr. Justice Stirling had before him the case of Wise *v.* the Metropolitan Electric Supply Company. It is an action brought by the occupiers and leaseholders in Manchester-street, Manchester-square, to obtain an injunction against the defendants, whose electric light station is situated on the east of the street. It was stated by counsel on Tuesday that the vibration caused by the machinery was so great that families were shaken in their beds, clocks stopped, and the people who lived in the nearer houses were always liable to small electric shocks on touching certain articles in the houses. For the defence it was contended that efforts had been made to prevent the nuisance. Sir Richard Webster having opened the case for the defence on Wednesday, the further hearing was adjourned until the 24th prox.

Beckenham.—A report has been presented to the Local Board by Mr. Gisbert Kapp on the question of supplying the district with electric light, under the recently acquired provisional order. He recommends the Board to carry out an installation. The scheme is divided into two stages, and he bases his figures on the following estimates: that in the first stage 100 houses will be served, with 2,650 10-c.p. lamps, and a revenue of £1,260; and that in the second stage 460 houses will be supplied, with 13,500 lamps, and a revenue of £6,610. He recommends a high-pressure alternating-current supply, and places the capital expenditure on the first stage at £11,000, and on the second stage at £27,000. Mr. Kapp's estimate as to the working expenses shows that there would be a loss on the first stage, while on the second stage a profit of £2,717 would be realised. The Electric Lighting Committee of the Board are considering the matter.

Messrs. Hodges and Todd.—It is gratifying to note that, notwithstanding the reports one hears in some quarters of general depression of business, some firms are extending their operations. We learn that Messrs. Hodges and Todd are doing so, for in addition to their Turnmill-street premises (which are inadequate for their increased business), they have taken extensive works at 30-42B. Hampstead-road, where they have ample facilities for manufacturing their various specialities of measuring instruments, switchboards, etc. These works are run by electric motors of the Immisch type, the current being obtained from the St. Pancras Vestry's mains, and which it is thought will prove to be as economical as any other form of motive power, whilst at the same time a great saving in time and labour is effected. The main switchboard which controls the whole shops is fitted in the testing-room. Messrs. Hodges and Todd have just completed an ammeter 1ft. in diameter for 2,500 amperes, and weighing about 50lb.

Stafford.—It was announced at a meeting of the Town Council last week that the Local Government Board had given formal sanction to the borrowing of £20,000 by the Corporation for a term of 25 years, and to the use of certain land at the gasworks for the purposes of electric lighting. Subsequently the report of the Electric Lighting Committee came up for discussion. The report stated that the committee recently attended on the site of the proposed electric supply station, when the Mayor performed the ceremony of cutting the first sod, and a vote of thanks was passed to him. The committee recommended that the foundations for the new buildings at the electric supply station should be put in by the staff of the department, and that tenders for the erection of the buildings be advertised for. The committee decided, instead of advertising for tenders for the engines, boilers, and dynamos, to obtain the same from certain well-known firms, whose names were submitted to the committee by Mr. Bell. In moving the adoption of the report, Alderman W. H. Peach explained that the latter course was adopted because the committee felt it was important that the work should be done well. Mr. Flamank seconded the motion, which was carried.

London County Council Engineering Staff.—The Establishment Committee have recommended, in connection with the electric lighting branch, that Messrs. H. W. Ridley and A. Champion, whose salaries are now £3. 3s. a week each, be placed on the permanent staff in the second class at the commencing salary of £162. 10s., and that the wages of Messrs. J. J. Thornton, J. Taylor, and T. O. Smith be increased from £2 to £2s. 2s. a week. There are two vacancies in the engineer's department—one caused by the retirement of Mr. R. Elliott, who was in the electrical branch, and the other by the resignation of Mr. E. R. Johnston, junior assistant in the drawing branch. Mr. Wakefield has been transferred to the electrical branch, and to fill his place in the drawing branch the chief engineer has submitted the name of Mr. W. H. Holthum, who is at present employed in a temporary capacity at £4. 4s. in the water branch. The committee recommend that the Council do authorise the employment for 12 months on probation of Mr. W. H. Holthum at a salary of £4. 4s. a week, and that to fill the second vacancy the Council authorise the appointment of an assistant in the third class at a commencing salary of £120, and that an advertisement be issued inviting applications for the position.

Anti-Sulphuric Enamel.—We have received from Messrs. Griffiths Bros. and Co., Macks-road, Bermondsey, a new circular giving particulars of anti-sulphuric enamel. This material—which was first prepared at the suggestion of Messrs. Crompton and Co., Limited, to meet the need of protection for metal and wood work from the destructive action of the fumes and spray in battery-rooms—is evidently fulfilling its purpose satisfactorily. The list of stations given in the circular where it has been employed comprises nearly all those in the United Kingdom in which accumulators are used. Judging from the reports upon the material contained in the circular, there is no longer any need to fear damage to buildings or fittings by the use of storage batteries, as the means of preventing it is simple and inexpensive. It appears that anti-sulphuric enamel is also found to be of use for a variety of purposes in the electrical trade. Being a good insulator, and drying quickly, it is serviceable for coating any articles that require a fine finish, and when applied to metal work it retains a wonderful flexibility. The list of users mentioned in the circular includes the leading firms in Europe, and this speaks for the usefulness of the article. Messrs. Griffiths Bros. and Co. also give a list of shellac varnishes, etc., manufactured especially for the electrical trades.

York.—At a meeting of the Town Council last week Mr. Alderman Milward, replying to Mr. Walker, who had asked for information as to the cost of electric lighting at the new law courts, said the total cost of the gas-engine and fixing the same was £202. 11s. 2d.; dynamo and everything connected with it nil, the committee having made an arrangement with the owners; cost of wiring and all other electric lighting apparatus in the new law courts building, £1,279. 1s. 1d.—total capital expended, £1,481. 12s. 3d. The total cost for one year, 1893, in wages of attendants of engine, etc., was £140. 15s. 8½d.; electrical engineers' repairing, etc., nil; oil, waste, £23. 4s. 11d.; gas for engine, £147. 7s. 6d.; water for engine, £21. 12s. 6d.; new lamps and materials for renewals of electric light apparatus, £29. 2s. 5d.; repairs to engine, dynamo, lamps, etc., £41. 7s. 1½d.—total for repairs, maintenance in wages and repairs, £403. 10s. 2d.; cost of gas lighting for one year, say 1892, in old police office and fire-engine station before business was removed to the law courts, £35. 12s. 8d. Alderman Milward could not say, because there was no separate account, the cost of gas in the Guildhall for that portion of business now provided for at the new law courts. The cost of the gas for the Council-chamber and suite of offices was £55 last year and £47 the year before. The total cost of gas for one year, now substituted by the electric light, was £35. 12s. 8d.

Derry Central Station.—On Tuesday the members of the Derry Corporation attended at the electric light station to inspect the engines and dynamos previous to the contractors proceeding to test the street lamps. Among those who attended were Dr. MacCullagh (mayor), Councillor Magee (chairman of the Lighting Committee), Mr. Collins and Mr. Mittlehausen (of Messrs. Siemens Bros.), Mr. Clamp (of Messrs. Johnson and Phillips), and Mr. David Brown (of Messrs. Alex. Brown and Sons, makers of the engines). General satisfaction was expressed at the way in which the work of the various contractors had been performed. After about an hour spent in examining the works, those present partook of cake and wine in the station on the invitation of the chairman of committee (Councillor Magee), who presided. In a few suitable words the chairman proposed the toast of "Success to the undertaking," coupled with the names of Messrs. Collins, Mittlehausen, and Brown, who severally responded, and expressed their confidence that the light would be a success, Mr. Brown predicting that Derry would soon be the best lighted city in the kingdom. Between eight and nine o'clock Mr. J. Brown started engine No. 1, Mr. Collins switched on the current, and the station was brilliantly illuminated by four lamps of 2,000 c.p. The light was greeted with hearty cheering, and Messrs. Collins and Brown were warmly congratulated by those present on the success attending the experiment. The exhibition was a success, and left no room to doubt that when in a few days the current is turned on to the street lamps the public lighting will not only be a success but afford satisfaction to the citizens.

Electrical Conversazione at Croydon.—At the Whitgift Grammar School, Croydon, on the 7th inst., a lecture on "Electricity" was delivered by Mr. W. Perren Maycock, M.I.E.E. The Mayor (Alderman S. L. Rymer) then presented certificates awarded for electrical knowledge by the Government Department of Science and Art to Mr. H. T. Haws, O.W., who has been elected student of the Institution of Electrical Engineers; a second class advanced certificate to Mr. F. R. McBride, O.W.; and a pass certificate to Messrs. J. M. Donaldson, B. Hopps, R. S. Long, O.W., G. F. Malden, and E. M. Simmins. Subsequently an electrical conversazione and exhibition of apparatus took place. Messrs. Wenham and Waters, engineers, of Croydon and London, exhibited electric incandescent lamps over lecture table, apparatus

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for domestic use, comprising electroliers, brackets, portable lamps, electric cooking and heating apparatus, etc. The current was supplied from steam-engine and dynamo in the cloisters, and the whole was fitted up under the direction of Mr. G. F. Grimes, O.W. Mr. W. J. Bishop, of George-street, Croydon, showed model dynamos and motors and parts of same, various forms of primary and secondary batteries, signalling apparatus, electric light fittings, transformers and vacuum tubes, measuring instruments, etc. The arc lamp on the top of the tower was lent by Mr. W. E. Wilson, O.W., and was supplied with current from the dynamo fixed by Messrs. Wenham and Waters. A model of new arc lamp, invented and constructed by Mr. W. S. Entwistle, O.W., was on view, and a drawing of a new type of telegraph instrument, designed by Mr. F. Johnston, O.W. Various kinds of telegraph, telephone, and other apparatus were shown as fitted up and made by boys of the electricity class.

The Phonopore.—The Phonopore Company have issued a circular, from which we extract the following: "The company call attention to the further improvements it has lately made in utilising existing telegraph wires and in doubling their carrying capacity. To meet the requirements of several of the railway companies, it has taken up the question of working a single-needle instrument by the phonopore system. This the company has accomplished; and as nearly all telegraphists read by the sound from the needle, it can now offer to railway companies a new sounder, worked by a handle similar to a single-needle instrument, by which an entire circuit can be duplicated. For example, given a single-needle or other circuit, having several stations on it, this new instrument can be attached to the existing wire at any or every station on the circuit, so that each station will have a double means of communication on the same wire, exactly as if there were two separate and distinct circuits. This instrument (or a phonopore telephone for speaking, with a special bell-call on the same wire) can also be attached to the block, bell, or train staff wires without any interference with their working. If the needle instrument is preferred to this new sounder, this can be applied to existing wires, but two wires are required for working the needle. A mixed circuit can be formed of the two systems, sounders and needles. Phonopore telephones can be attached to ordinary telegraph and block wires, and conversation can be carried on distinctly in spite of any ordinary induction. The Phonopore Company now offers the following systems: (1) the improved phonopore telegraph, for working Morse printers and ordinary sounders; (2) the needle phonopore, for working single-needle instruments; (3) the new phonopore sounder, worked by a handle similar to the ordinary single-needle telegraph instrument, or by a Morse key if desired; (4) phonopore telephones, which can be placed on either bell, block, train staff, or ordinary single-needle circuits. On several occasions when a wire has broken or become defective, and the ordinary telegraph in consequence became unworkable, the phonopore telegraph remained undisturbed and continued to work satisfactorily although on the defective wire. The system can be seen at work at the company's offices, Faraday House, Charing Cross-road, London, W.C."

PROVISIONAL PATENTS, 1894.

MARCH 5.

4572. **Improvements in telephonic transmitters.** Charles Adams-Randall, 1, The Avenue, Bedford-park, London.

4575. **Improvements in connection with electrical tramways.** Ernest Edward Vaughton, 12, Cherry-street, Birmingham.

4610. **An improved temperature regulating device for electricity meters.** Ernest Francis Moy, 433, Strand, London.

4635. **Improvements in galvanic batteries.** Hermann Wehmann, 65, Chancery-lane, London.

MARCH 6.

4647. **Improvements in electric lighting by incandescence lamps arranged in series.** Thomas Robert Burrell and Frederic Fowkes, Hawkeshead, Ambleside, Lancs.

4691. **Improvements in apparatus for connecting and disconnecting electrical circuits.** Andreas Peter Lundberg, Gustaf Charles Lundberg, and George Pegg, Bradbury Electrical Works, Bradbury-street, Kingsland, London.

4724. **Improvements in and relating to secondary batteries.** Octavius March, 45, Southampton-buildings, Chancery-lane, London.

MARCH 7.

4788. **Improvements in standard resistance boxes.** Francis Henry Nalder, Herbert Nalder, Charles William Scott Crawley, and Alfred Soames, 16, Red Lion-street, Clerkenwell, London.

4805. **A new or improved method of lighting cycle lamps by means of electricity.** Joseph Muffley Klingelsmith, 22, Glasshouse-street, Regent-street, London.

MARCH 8.

4849. **Improvements in casings, culverts, or means for supporting and protecting electrical conductors.** Gerald St. John Day and Samuel Allmark, 64, Barton-arcade, Manchester.

4904. **Improvements relating to electric lamps.** Robert Hacking, George Brand, Arthur Gibson Howitt, and John Johnstone, 78, Fleet-street, London.

4909. **Improvements in or relating to combined targets and electrical indicating apparatus.** George Henry Collins and Charles Stuart Jones, 46, Lincoln's-inn-fields, London. (Complete specification.)

4910. **Improvements in or relating to the distribution and utilisation of electricity.** William Lloyd Wise, 46, Lincoln's-inn-fields, London. (Edgar Modesse, Belgium.)

4911. **Improvements in or relating to electric supply apparatus, such as alternators and transformers, applicable also to other purposes.** William Morris Mordey, 46, Lincoln's-inn-fields, London.

MARCH 9.

4945. **A combined electricity meter and automatic switch with apparatus for registering the position of an index or pointer.** Ernest George Pink, 10, Seville-place, Dublin.

4969. **Improved device for converting and making oil lamps suitable for electric light.** Somerset Frederick Gough-Calthorpe, 16, Upper Thames-street, London.

4987. **An improvement in arc electric lamps.** Edward Car stensin de Segundo, 28, Southampton-buildings, Chancery-lane, London. (Complete specification.)

4993. **An improvement or improvements in joints for suspending electroliers.** William Whitehouse and Henry Pinnell, 7, Staple-inn, London.

5001. **Improvements in connection with electric fuses and switches.** Albert Essinger and Thomas Harden, 55, Chancery-lane, London.

5002. **Electric lamps.** Horace George Nichols, 11, Argyll-street, Regent-street, London.

5003. **Improvements in regulating electric motors.** James George Willcox Aldridge, 40, Chancery-lane, London.

MARCH 10.

5025. **Improvements in electric rail or tramway systems.** Michael Holroyd Smith, 55, Chancery-lane, London. (Complete specification.)

SPECIFICATIONS PUBLISHED.

1885.

154. **Electric telegraphy.** Muirhead. (Second edition.)

1888.

16212. **Phonographs.** Gouraud. (Edison.) (Third edition.)

1889.

3402. **Metering electric energy.** Scott. (Second edition.)

1890.

8197. **Graphophones.** Johnson. (Edison United Phonograph Company.) (Second edition)

1891.

16572. **Dynamo-electric machines and motors.** Sayers. (Second edition.)

1893.

3666. **Distributing electrical energy.** Lowrie.

4144. **Electrodes.** Armstrong.

5470. **Electric signalling on railways.** Sibery.

6254. **Electric arc lamps.** Shepard.

7407. **Electric meters.** Jones.

7714. **Electric targets.** Wyatt.

7935. **Arc electric lamps.** Buchet.

8331. **Electrical lock and block apparatus for railway points and signals.** Tyer.

19146. **Telephone bookholders, etc.** O'Brien.

23633. **Electric motor.** Parkin.

23744. **Lighting railway trains by electricity.** Urquhart. (Ysasmendi.)

24871. **Dry batteries.** Johnson.

25016. **Rosette for electric wires.** Lake. (Rand.)

1894.

95. **Telephonic transmission.** Eckert.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	2¾
— Pref.	—	2¼
Charing Cross and Strand	—	5
City of London	—	11½
— Pref.	—	13½
Electric Construction	—	½
House-to-House	5	1½
India Rubber, Gutta Percha & Telegraph Co.	10	23½
Liverpool Electric Supply	5	6¾
	4½	5½
London Electric Supply	5	1
Metropolitan Electric Supply	—	8¾
National Telephone	5	4¾
St. James', Pref.	—	8½
Swan United	3½	3¾
Westminster Electric	—	6

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NOTES.

Christiania.—An electric tramway has just been set in operation.

Derby.—The new School Board offices in Becket-street are to be lighted by electricity.

Civil Engineers.—The annual dinner of the Institution of Civil Engineers took place on Saturday evening.

Oswestry.—The seal of the Council has been attached to the agreement with the Oswestry Electric Light Company.

Madras.—The shareholders of the Madras Electric Tramways Company have appointed a local board, sitting at Madras.

Windsor.—New electric lighting proposals are before the Corporation, and a committee has been appointed to report on them.

New Atlantic Cable.—The Commercial Cable Company expect that their new cable will be completed by the middle of July.

Darwen.—A correspondent asks whether the Corporation intend to light any other building by electricity than the technical school.

Bradford.—The Bradford Gas and Electricity Supply Committee have decided to grant the men in their employ an eight hours' day.

Guildford.—The Town Council have again postponed their decision in regard to the provisional order which is being promoted by a company.

Calcutta.—The Oriental Telephone and Electric Company, Limited, have opened a branch for electric lighting work at 1, Lall Bazar, Calcutta.

Croydon.—The County Council have decided not to expend for the present the £700 already provided for wiring the new municipal buildings.

Buckingham.—A meeting of the Town Council was held on Monday to consider a tender from Messrs. Parr and Gillies for the electric lighting of certain lamps.

Ayr.—The Town Council are ascertaining the number of arc lamps which will be required for lighting the town by electricity, and the number of lamps likely to be needed by householders.

Brighouse.—The Town Council have received an application from the Brighouse Industrial Society for a supply of gas for a gas-engine to be used in lighting their premises with electricity.

Telephony.—The last length of wire in the London to Dover telephone system was fixed on Saturday, and telephonic communication between Dover and the Metropolis was established for the first time.

Sewage Purification.—Mr. Ashmead, the surveyor to the Bristol Sanitary Committee, has been instructed to prepare a report on the different systems of dealing with sewage, including electrical methods.

Maidstone.—The Local Board have resolved not to proceed with their electric lighting scheme, but to negotiate with electricity supply companies with a view to the provisional order being taken over by one of them.

Lecture.—Mr. F. F. Bennett, M.I.E.E., of Messrs. Bennett and Druce, Preston, delivered on the 13th inst. a lecture before the Preston Scientific Society, at the Guildhall, entitled "What is a Board of Trade Unit?"

Extensions at Blackpool.—A Local Government Board enquiry was held last week to examine the advisability of sanctioning a further loan of £24,000 for the purposes of extensions in connection with the electricity works.

Brighton.—A Local Government Board enquiry has been held regarding an application of the Corporation to borrow £32,500 for acquiring the goodwill of the Brighton and Hove Electric Lighting Company, and to make extensions.

Brechin.—At the last gathering of the Town Council, Mr. Jamieson gave notice that at next meeting he would move that the Council apply to the Board of Trade for a provisional order for the introduction of electricity for lighting.

Electric Lighting in Londonderry.—On Saturday evening about two-thirds of the city were lighted by electricity for the first time. The installation consists of 160 2,000-c.p. arc lamps of the Brockie-Pell type. The installation has been carried out by the Corporation.

Walsall.—The Board of Trade having provisionally approved of the electric-lighting scheme for the borough, the town clerk has applied to the Local Government Board to hold an enquiry with regard to the application of the Council for a loan to carry the scheme into effect.

Municipal Electric Lighting.—Under the title of "A Short Practical Treatise on Municipal Electric Lighting," Mr. F. Hastings Medhurst, M.I.E.E., has issued a pamphlet which mainly consists of a reprint of the Electric Lighting Acts, 1882 and 1888, and copies of provisional order and transfer.

The Antwerp Exhibition.—A meeting of the committee of the British section of the Antwerp Exhibition was held a few days ago at the Mansion House. It was decided to make a special effort to obtain the adhesion of the leading agricultural implement makers and electrical engineers.

New Cable.—The new telegraph lines of the Pacific and European Telegraph Company, Limited, between Buenos Ayres and Valparaiso have been set in operation. In conjunction with the cables of the Eastern, Brazilian Submarine, and Western and Brazilian Telegraph Companies, this affords a new direct telegraph route to Chili, Peru, and Bolivia.

Society of Arts.—The council will proceed to consider the award of the Albert Medal for 1894 early in May next, and they therefore invite members of the society to forward to the secretary, on or before April 14, the name of such men of high distinction as they may think worthy of this honour. The medal was struck to reward "distinguished merit for promoting arts, manufactures, or commerce."

The Oldham Central Station.—The principal streets of Oldham were on Thursday of last week for the first time lighted by electricity. The plant is sufficient for simultaneous lighting of 2,500 incandescent lamps of 8 c.p. There are four dynamos, and the total horse-power is 320. The Corporation obtained power to borrow £27,000 to carry out the scheme, which has been superintended by Prof. Kennedy.

Electric Lighting of Breweries.—"It is rather surprising," remarks the *Brewers Journal*, "that electric lighting has not made more headway in English breweries. It has recently been shown to be fatal to the life of bacteria, or at any rate of certain bacterial organisms more potent in power than the majority of those appearing in beer. We have always thought that a well-ventilated fermenting-room, without natural light, but illuminated by electrical means, would be a step in the right direction."

Bolton.—During the past month building operations at the Spa-road electricity works have made rapid progress,

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and it is hoped that the buildings will be practically completed and the electric current turned on by July. The work of laying down the transformer-chambers, of which there are to be four—one at the junction at Knowsley-street and Deansgate, one in Churchgate, one at the junction of Great Moor-street and Bradshawgate, and another at the Town Hall-square end of Hotel-street—is now being proceeded with.

Royal Institution.—The following are, among others, the lecture arrangements after Easter: Prof. J. A. Fleming, four lectures on "Electric Illumination"; Prof. Dewar, three lectures on "The Solid and Liquid States of Matter"; Captain Abney, three lectures on "Colour Vision" (the Tyndall lectures). The Friday evening meetings will be resumed on April 6, when a discourse will be given by Prof. Victor Horsley on "Destructive Effects of Projectiles"; succeeding discourses will probably be given by Prof. Oliver Lodge, Prof. C. V. Boys, and other gentlemen.

The Abatement of Smoke.—A smoke-abatement experiment is in progress at the City Sawmills, Glasgow. An apparatus invented recently by Colonel Dulier has been applied to one of the boilers, and the results are said to be of an encouraging kind. The object of the appliance is not the consumption of the smoke, but the removal of the soot and sulphurous acid from the gaseous products of combustion. The boiler experimented on is of the Babcock and Wilcox water-tube type, and drives an engine of 220 h.p. Mr. R. R. Tatlock, city analyst, who has on several occasions tested the appliance, reports favourably on it.

The Institution.—An ordinary general meeting of the Institution of Electrical Engineers, will be held on Thursday next, the 29th inst., when the balance-sheet for 1893 will be presented. The discussion will be continued of Mr. Mordey's paper on "Parallel Working Through Long Lines." Papers on the following subjects will be read: (1) "A Universal Shunt-box for Galvanometers," (2) "Transparent Conducting Screens for Electric and Other Apparatus," and (3) "An Astatic Station Voltmeter," by Prof. W. E. Ayrton, F.R.S., past-president, and Mr. T. Mather, associate; and (4) "On the Best Resistance for the Receiving Instrument with a Leaky Telegraph Line," by Prof. W. E. Ayrton, F.R.S., past-president, and Mr. C. S. Whitehead, M.A.

The Scientific Work of Tyndall.—Lord Rayleigh lectured on Friday evening at the Royal Institution on "The Scientific Work of Tyndall." The lecturer said that it was fitting that the memory of Tyndall should be honoured in the place where he had delivered so many brilliant lectures. Tyndall was a personality of exceeding interest. All that the lecturer could hope to do was to bring up to their recollection the more salient points of his work, and to illustrate them, where possible, by experiments of his own devising. There were three distinct parts of Tyndall's work, which Lord Rayleigh then proceeded to pass in review—that relating to heat, especially dark radiation; that relating to sound; and that relating to the behaviour of small particles such as dust. Each of these departments was illustrated by a variety of experiments, and the lecturer was frequently applauded for the success with which they were carried out.

Electricity and Scenic Effects.—We understand that the electrical apparatus made and installed by the Lithanode and General Electric Company, Limited, of 64, Millbank-street, Westminster, S.W., for Mr. Barrett in the Lyceum pantomime of "Cinderella," has been so successful that Mr. Barrett has determined to take the whole arrangement with him to New York. The pantomime, which terminated on Saturday last, is to be reproduced in Abbey's Theatre, in New York, on the 23rd prox. The Lithanode Company have undertaken to send all their apparatus across and instal it for Mr. Barrett. We believe that this is the first time that such a company has ever been taken to America, and it is certainly the first time that electrical apparatus for scenic effects has been transplanted as a whole from this country to New York. It is now generally admitted that the work done by the Lithanode Company at the Lyceum Theatre has been the most successful attempt that has ever been made in this direction.

Electro-Harmonic Society.—The last smoking concert of the season will take place on Friday next, the 30th inst., in the Banquet-room at the St. James's Hall Restaurant, Regent-street, W., commencing at eight o'clock. The following is the programme:—Artistes: The London Glee Singers, Mr. G. Beart, Mr. F. Pinnington, Mr. A. Pinnington, Mr. R. Fisher, Mr. Arthur Thompson, Mr. Arthur Barlow; solo violinist, Mr. T. E. Gatehouse; solo pianist and accompanist, Mr. Alfred E. Izard; silver bells, Mr. R. B. Hopkins; humorous sketches, Mr. Walter Banks. Musical directors: Messrs. T. E. Gatehouse and Alfred E. Izard. (A Blüthner Aliquot concert grand piano will be used.) Programme—Part I.: Madrigal, "This Pleasaunte Monthe of Maie" (Beale), the London Glee Singers; new song, "Arab Love" (C. Deacon), Mr. Arthur Barlow; pianoforte solos (*a*) "La Fileuse," (*b*) "Tambourin" (Raff), Mr. Alfred E. Izard; song, Mr. Arthur Thompson; silver bells, "Intermezzo" ("Cavalleria Rusticana" (Mascagni), Mr. R. B. Hopkins; harmonised melody, "The Banks of Allan Water" (Cantor), the London Glee Singers; violin solo, "Ballade and Polonaise de Concert" (Vieuxtemps), Mr. T. E. Gatehouse; humorous sketch, Mr. Walter Banks. Part II.: Humorous part song, "The Deil's awa' wi' th' Exciseman" (Hedgecock), the London Glee Singers; song, "Biddy Aroo" (air by F. Maitland), Mr. Arthur Barlow; silver bells, "Love's Golden Dream" (L. Lennox), Mr. R. B. Hopkins; song, Mr. Arthur Thompson; humorous part song, "The Goslings" (Dr. J. F. Bridge), the London Glee Singers; violin solo, "Romance in F" (Beethoven), Mr. T. E. Gatehouse; humorous sketch, Mr. Walter Banks.

The Aix-la-Chapelle Central Station.—Messrs. Schuckert and Co., of Nuremberg, were, in May, 1892, instructed by the Town Council of Aix-la-Chapelle to erect an electric light station in a central position in the town, a stipulation being that the firm should run the station on their own account for a certain period of years. Work was commenced in July of the same year, and the station was set in operation by the close of 1892. Mr. F. Uppenborn gives an account of this station in the *Electrotechnische Zeitschrift*, from which we take the following particulars. The buildings are divided into three main sections, which comprise the boiler-house, the machinery-house, and the accumulator-house. There are three boilers, made by Messrs. Jaques Piedboeuf, of Aix-la-Chapelle, and there is room for five in addition. Dry steam is produced, as is necessary for the triple-expansion engines employed. The steam-pipes are made of wrought iron, with the exception of the connections with the boilers and steam-engines, and the bends are of copper. The power plant consists of two vertical triple-expansion engines, made by Mr. G. Kahn, each of which is coupled direct to a Schuckert dynamo. At 150lb. pressure in the high-pressure cylinder and 120 revolutions per minute, the normal output is 350 h.p. The maximum power obtainable is 420 h.p. There is space for two further steam-dynamos, each of 600 h.p. The capacity is from 270 to 280 kilowatts. In the accumulator-house there is employed a battery of Tudor cells of the Hagen Accumu-

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lator Manufacturing Company's type, and which have a capacity of 1,610 ampere-hours. The network of conductors was at first made for about 14,000 16-c.p. incandescent lamps in use simultaneously. The installation has proved very successful.

Electromagnetic Rotation of the Plane of Polarisation of Acids.—Mr. O. Humburg deals, in the *Zeit. Physikal Chem.*, with the subject of the electromagnetic rotation of the plane of polarisation of some acids and salts in different solvents. He states that in order to ascertain whether a connection exists between the magnetic rotation of an electrolyte and its electrolytic dissociation, a number of fatty acids and of inorganic salts were examined in solution in water and in other solvents. Benzene and toluene were used as solvents for the fatty acids, and methylic alcohol for the salts examined. The rotation of the fatty acids is independent of the solvent, and is the same in aqueous solution, in benzene, and in toluene; this holds even in the case of the chloracetic acids, which must be regarded as strongly dissociated in aqueous solution. The inorganic salts taken were potassium iodide, sodium and barium bromides, and ammonium nitrate. The molecular conductivities of these salts is much smaller when measured in the methylic alcohol solutions than in water, and therefore, as was to be supposed, the dissociation is relatively much smaller in the first case. The rotation, however, remains practically unchanged with change of solvent, showing that it is independent of the dissociation. From the results of these experiments, therefore, it appears that electrolytic dissociation has no appreciable influence on the magnetic rotation. The rotations of chlorine and bromine derivatives of some of the fatty acids and of some hydrocarbons were measured, and from these the atomic rotations of chlorine and bromine were calculated. The numbers obtained were: for chlorine 1·606 in the case of the fatty acid derivatives, and 1·675 from hydrocarbon derivatives; for bromine 3·525 and 3·563 in corresponding cases. The numbers are practically identical in the two series.

Electric Traction on Roads.—A letter has been published in the *Times* referring to "electric road traction." The writer, "C. S.", says: "I have noticed with interest the report of the running of an electrically-propelled parcels van through the streets of the City, but at the same time my interest has been tinged, if not altogether clouded, by surprise as to why so much valuable time, energy, and money should be thrown away in attempting to establish a mode of street locomotion which the Locomotives Act as it at present stands renders a practical absurdity. Being interested in developing a scheme of electric traction for light vans, I wrote to the Commissioner of Police as to the conditions under which such vehicles would be permitted to be used in the Metropolis, and I received in reply the following letter: 'With reference to your letter of the 8th inst., I am directed by the Commissioner of Police of the Metropolis in reply to acquaint you that an electric van is a locomotive within the meaning of the Locomotives Acts, and is subject to the provisions of those Acts as regards not going at a greater speed in a town than two miles an hour, having a man 20 yards in front, and having three men to drive, etc.—C. Bathurst, chief clerk.' The above statement most certainly precludes the employment of electrically-propelled road vehicles for all practical purposes. It is possible, however, that some one of our strong and free legislators may be induced to take this matter up with a view to the alteration of the Locomotives Acts, in so far as their restrictive clauses affect the practical employment of electrical vehicles used for the conveyance of passengers, goods, etc., and thus opening up a fresh branch of industry, benefiting thereby the community at large by reducing the dangers and discomforts attending street locomotion, and by decreasing the number of the unemployed." We are somewhat surprised at the contents of the letter received by "C. S." If we remember rightly, Mr. Radcliffe Ward was informed a few years ago by the Scotland Yard authorities that licenses would be issued for the operation of electrical omnibuses, or, for that matter, electric parcel vans, and that they would not be comprised under the Locomotives Acts. If this assumption is correct, it is difficult to understand the altered state of affairs. Perhaps Mr. Ward will be able to give information on the subject.

The Antwerp Hydro-Electric Installation.—The installation of the works which the Hydro-Electric Company has carried out at Antwerp for the distribution of electricity is based on a system of Prof. François Van Rysselberghe. Our contemporary the *Engineer* states that the system consists, first, in the employment of water under pressure, distributed without appreciable loss, the pressure being obtained either from a natural fall or from steam-pumps distributing water under a pressure of 52½ atmospheres; secondly, in the creation of centres of production or distribution, permitting of the employment of this water under pressure for various industrial purposes, or its use at these centres for the generation of electricity. It is for effecting this transformation of the hydraulic power into electric energy at various stations or centres that the special motors and machinery have been designed by M. Van Rysselberghe, and for the operation of which the pumping machinery, distributing arrangements, and accumulators have been designed. A special hydraulic turbo-electric generator has been designed for use in these district stations. The Rysselberghe motor makes it possible, it is said, to maintain a uniform potential throughout any part of the mains in service within about two volts of the 110 volts used on the circuit. The system then differs from those hitherto employed in that it requires or employs both hydraulic and electrical methods in the distribution of power by electricity, or electricity for lighting purposes, and its author considers that the advantages secured are of great importance. The system provides a public hydraulic power supply system for small or large consumers, and the supply to workpeople working in their own houses is expected to afford a large demand. At all events, it is for the employment of this hydro-electric system that the company already referred to has established works at Antwerp. At present these works contain two horizontal Sulzer compound, receiver steam-engines, with variable expansion gear to the high-pressure cylinder, fixed cut-off to the low. The engines are arranged to work with or without the condensers. By a continuation of the piston-rod of each cylinder, each engine operates a hydraulic pressure pump on the Riedler differential action system. The pumps are strongly connected to the bed-plate of the engines. There are four of these pumps taking their water from a reservoir placed under the floor of the machinery hall. The accumulators are of cast iron, and have each a piston of 500mm. in diameter, or 19 69in., and of 7,000mm., or 23ft. stroke. The steam necessary for the engines is produced by a battery of five boilers, each having two furnaces with Fox's corrugated flues and 16 Galloway tubes; they are loaded to a safety-valve pressure of eight atmospheres, or 120lb. The water, after passing the accumulators, is passed into the distributing pipes, which are of steel, in diameters varying from 300mm. to 131mm., four sizes being used, or from 11·81in. to 5·15in. All the pipes have been tested under pressures varying from 150 to 200 atmospheres, and are provided at intervals with stop valves. The length of distributing pipes will be about 7½ miles, and on this

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length there will be 10 district central stations for the production of electric current, one of which has been at work in the Place Verte since 1892. Each of these stations will send electric current to a radius of 500 metres, or 1,640ft., and the underground mains will have a length of nearly 10 miles.

The Worcester Central Station.—The scheme for the electric lighting of this town is progressing. It was worked out under the late city surveyor, Mr. S. G. Purchas, by his assistant, Mr. Thomas Caink, A.M.I.C.E., in consultation with Mr. W. H. Preece, F.R.S. Mr. Caink has succeeded Mr. Purchas in office, and as he has all along acted as the electrical engineer, the change will not affect the progress of the work. The installation, it is estimated, will cost the city something over £42,000. The works are about two miles and a half from the city, on the road leading to Upton and Malvern. The station will consist of two blocks of buildings standing at right angles to each other, one stretching across the river, the other with its back to the water and its front on the road, looking towards the city. The building across the river will be 102ft. by 42ft., and will contain the generating machinery. The arches on which it is to stand will be utilised for the turbine-pits, and the building itself will contain the engine and dynamos. The other block, that facing the road, will be the boiler-house. There is water power enough in the course of the year to generate more electricity than the yearly consumption is likely to be. But the supply is not continuous. When the Severn is in flood the water backs up the Teme, and the "fall" upon which the mill power depends is wholly or partially done away with, and during a very dry summer the diminution of the flow from above may cause practically a stoppage. The plant has been laid out on the lines of what is believed to be an economical compromise. Powerful steam-engines must be provided for emergencies, and it has been thought undesirable that these and the capital they represent should be too long unemployed. Therefore, the water power the works will develop will not be quite equal to the possible maximum consumption. With the river in a normal condition, it will be only during this maximum period of the 24 hours' consumption that the water power will require supplementing. The contractors for the machinery and electrical plant are the Brush Electrical Engineering Company. The water power will be utilised by four turbines of the Victor pattern. Something like 350 h.p. will be furnished by these motors, but they are capable of developing 700 h.p. or 800 h.p. As it may be necessary at times to produce the whole of the current by steam power, four boilers equal to 900 h.p. will be put in. They will be water-tube boilers, having an exceptionally large heating surface. Four Falcon vertical compound engines will be used. The generators will be Mordey-Victoria alternators. The boiler-house will accommodate four more boilers, and in the engine and dynamo house space for corresponding extension will be left. The current will be taken underground to the city by mains at a pressure of 2,000 volts, but transformers will be placed at various points bringing the tension in the distributing mains down to 105 volts. The work is being superintended on the spot by Mr. Leonard Wigan, A.M.I.C.E.

The Waterloo and City Electric Railway.—This electric railway, the construction of which is about to be commenced, will be about a mile and a half in length. One terminus will be right under Waterloo Station, and the other will be close to the Mansion House, where there will be subterranean communication with the Central London Electric Railway. There will be no connection of the actual lines, but the booking office at the terminal station of the City and Waterloo line will be in direct communication by subway with the booking office of the Bank Station of the Central London, so that the two lines will afford mutual assistance. On the new railway there will be, as at present arranged, only the two terminal stations. The generating station will be erected to the south of Waterloo, between Aubin-street and Lambeth-marsh. There will also be the shunting ground for the new line, which from this ground will run across the main railway overhead at right angles. The electric line will be only about 35ft. below the platforms of the South-Western, and it is not expected that lifts will be necessary. Communication between the platforms above and those below will be by steps and inclines, and by running one line across at right angles with the other, the underground line is rendered easier of access from any part of the great main line terminus than it would be by any other arrangement. From all the platforms above, steps and inclines will lead directly down to the trains for the City. From this lower station two tubes, 12ft. in diameter will run out northwards, pass under the South-Eastern Charing Cross line into York-road, at the point where it joins the Waterloo-road, and thence into Stamford-street, dropping down towards the river-level with an incline of 1 in 60. The two lines, side by side, will run under Stamford-street as far as Hatfield-street, and then turn north, and for about 150 yards will run under private property, at 55ft. to 60ft. below the street-level. The line will dive under the river a little east of Bull Stairs-alley, at about 160 yards west of Blackfriars Bridge. From this point it will run diagonally across under the embankment at the north-west corner of Blackfriars Bridge, and thence into Queen Victoria-street. Under the middle of the river the rails will be 60ft. below Trinity high-water mark, and there will be a space of 20ft. between the tops of the tunnels and the bed of the river. The railway will at the City terminus be at a depth of about 63ft. below the streets, and here it will communicate with the Central London, which will lie at a depth of 80ft. This line is likely to cost half a million of money. To carry it overhead in the usual way would, it is computed, cost at the very least three millions. This new line will terminate in the City a little to the east of Bucklersbury, in a property just opposite the City Safe Deposit, and having an entrance from Queen Victoria-street and from the Poultry. As regards the rolling-stock of the new line, experience on the City and Southwark has suggested some modifications. It has been found that the existing electric railway would have done much better but for the limited dimensions of its carriages. Their tunnels are only 10ft. or 10ft. 6in. in diameter. The City and Waterloo will make its tunnels 12ft. in diameter and somewhat larger at the curves so as to allow for the turning of the carriages. The carriages will be 9ft. wide, and will each take 50 passengers. Trains will be composed of seven carriages, so that a full train-load will be 350.

Lightship Communication with the Shore.—The Royal Commission on Electrical Communication with Lighthouses and Light-vessels recommended that five light-vessels be immediately connected with the shore by a telegraphic cable—viz., the "Goodwin," at the north end of the sand; the "Kentish Knock," at the Thames entrance; the "Shipwash," off the Suffolk coast; the "Hasborough," off the Norfolk coast; and the "Scarweather," off the northern shore of the Bristol Channel to the southward of Swansea Bay. From the experience gained by the experimental connection of the "Sunk" light-vessel with the shore for a continuous period of 18 months, it has been found

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that there is no serious difficulty in maintaining the electric connection between a lightship and the shore. The plan adopted in the case of the Sunk Lightship was on the principle that the electric cable should be so led away that it could not get entangled with the mooring chain. To effect this, two mushroom anchors were laid a considerable distance apart, to each of which was attached a sufficient length of chain cable. These lengths of chain were brought together and joined to a large swivel, and from the top of the swivel a single veering chain passed into the lightship through the hawsepipe. This swivel, designed by Mr. F. Bedwell, of the Telegraph Construction and Maintenance Company, had a circular hole through its centre, and a light electric cable from the vessel was carried through this hole and spliced on to the main electric cable, which ran in quite a different direction from that of either of the two arms of mooring chains and anchors. One great necessity appeared to be that the swivel should be always kept above the sea bottom, so as to ensure that the telegraph cable was kept free from contact with the mooring chains. After some experience with this plan, of course involving some failures and fractures, it was ultimately found practicable to keep the electric cable intact without interfering materially with the safe and secure riding of the ship. As she swung round with the tide the light electric cable was passed over by hand, when necessary, to the other side. It is now satisfactory to chronicle the fact that another important lightship has just been put in electric communication with the shore. The Kentish Knock Lightship is in every sense an outside vessel, and is moored in about 12 fathoms at low water. She is 18 miles from the nearest land, and marks the sandbank from which she takes her name in the sea approaches to the River Thames. The nearest land is the North Foreland, and it is from the post office at Kingsgate that the submarine cable is now taken to the lightship. Owing to the much more exposed position of this vessel than that of the "Sunk," it has been necessary to adopt greater precautions in respect of the moorings. Instead of two arms of moorings there are four. The laying of these moorings and fixing the ship to them has been carried out, under the directions of the Elder Brethren of the Trinity House, by the superintendent of the London district, Mr. Hattersley, and Mr. Reading, the master of the Trinity steamer "Vestal." All thing being ready for the reception of the electric cable, the Post Office authorities were informed, and the cable ship "Monarch" was despatched to lay the submarine cable from Kingsgate. Under the personal directions of Captain Lumsden, submarine superintendent of the Post Office, and other officers of the Department, this work was quickly done and the cable brought across the *embouchure* of the Thames to the Kentish Knock. A lighter cable was then reeved through the central hole in the swivel and taken inboard, the other end being spliced on to the main cable, and at 3 p.m. on Wednesday of last week a message was sent through from the lightship to the General Post Office, to the effect that the first of the permanent lightship cables had been successfully laid and communication established.

Polyphase and Continuous Currents at Bockenheim.—In a recent issue of *La Lumière Electrique* a description is given by M. C. Jacquin of the electricity works at Bockenheim, a small town on the northern outskirts of Frankfort-on-the-Maine. The station was carried out by Mr. Lahmeyer on the system he showed at the Frankfort Exhibition. Current is transmitted from the station to the centre of the town at a sufficiently high potential to reduce the cost of the mains, and yet not too high to be detrimental to the good working of motors. With, say, 600 or 1,000 volts, the motors might be connected directly to the high-tension mains, which would run through the principal thoroughfares, and for the lighting of which arc lamps would be run in series from these mains. Next to these would be laid low-tension mains, coupled to the former through special transformers, reducing the pressure from 1,000, or 600, volts to 100. The low-tension mains are connected from a point near the generating station to low-tension dynamos, which are also employed for exciting the high-tension machines. Incandescent lamps, isolated arc lamps, and small motors are run in parallel from the low-tension mains. Since the introduction of polyphase currents and their success at Lauffen, it was clear to Mr. Lahmeyer that his system might be rendered more simple and practical by their use. The commutators on direct-current dynamos working at 1,000 volts, would offer considerable trouble when compared with the simple collectors on polyphase machines. But matters were simplified still further by employing a fixed armature for the latter machines, producing triphase currents at only 80 volts in the station, the pressure being raised to 600 volts on the feeders by similar transformers to those used at Lauffen; these feeders being connected to three-wire ring mains. A sub station contains a special transformer, the primary of which is connected to the three wires of the high-tension mains, the secondary delivering a continuous current at 110 volts into two-wire low-tension mains, to which lamps, motors, or accumulators are connected. The dynamos used for exciting the triphase alternators also feed into the continuous-current mains at a point near the station, and are capable during periods of light load of alone supplying current. The station is at some distance from Bockenheim. The boiler-house measures 7·5 × 17·5 × 12·5 metres, and contains two boilers, with room for a third. Supply water is obtained from the mains. Each boiler has a heating surface of 90 square metres, and can produce 350 kilogrammes of steam per hour at 10 atmospheres pressure, with a consumption of 80 grammes of coal per kilogramme of steam. The machine hall has the same dimensions as the boiler-house. Two independent groups of machines are placed in parallel lines. The switchboard is at the end of the hall, with a raised platform three metres from the floor. There are two horizontal compound Corliss engines, with tandem cylinders, of 250 h.p. each. The field magnets of the triphase alternators are similar to those used on the Lauffen machines—each disc having 24 claws on its periphery, and the two discs when in position give 48 polar surfaces of alternating polarity. The diameter of these field magnets is 2·80 metres, which are worked directly from the engine shaft. The 50-h.p. continuous-current dynamos are belt-driven from the engine flywheels, and run at 600 revolutions per minute. In a chamber under the dynamo-room is placed a condenser, working at 650mm. vacuum. The hot water from the condenser runs in thin streams down a number of boards arranged in steps, and, after being cooled in this way, is used for cooling the condenser; by this simple method it is possible to cool 40,000 litres of water per hour. The triphase alternators are very similar to those used at Lauffen. The fixed armature consists of 144 copper bars 20mm. in diameter, insulated with asbestos, and so connected that they form three distinct circuits, each of 48 coils, these circuits ending in three terminals on the dynamo. The machines are of the simplest construction. Each triphase machine has an output of 150 kilowatts, giving 1,850 amperes at 80 volts. The two four-pole continuous-current dynamos, of the Lahmeyer type, have an output of 36 kilowatts, 30 amperes at 120 volts.

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PRACTICAL INSTRUMENTS FOR THE MEASUREMENT OF ELECTRICITY.

BY J. T. NIBLETT AND J. T. KWEN, B.SC.

XVIII.

(Continued from page 231.)

RESISTANCE, *continued.*

Testing Sets.—Before an electric telegraph or telephone cable is put into use, it is usual to subject it to three distinct tests to ascertain its conductor resistance, insulation resistance, and electrostatic capacity. These three properties are usually termed resistance, insulation, and capacity, and it will be observed that they are all specific properties of the conductor itself, and totally independent of whatever current may be flowing in it at any given time. In the case of an ordinary electric lighting circuit, only the first two of these—the conductor and insulation resistances—are measured, and very often the insulation resistance alone is all that it is thought necessary to be ascertained. It is essential, however, that this last value should be accurately determined before the circuit is put into use, to ensure that the insulation is quite sufficient for the purposes of the installation, and to comply with the rules drawn up by the various fire insurance companies for the prevention of fire risks.

It is therefore of the highest importance to the electrical engineer that he should be provided with some convenient device for measuring whichever of these properties he desires; and the apparatus employed must be of sufficient portability to be easily transported from place to place, and also must not be at all likely to get out of order, especially in the case of instruments for measuring light and power circuits. Such a self-contained set of instruments, whether for measuring any one or two or all of these properties, is termed a *testing set.* Testing sets for the measurement of the third property—electrostatic capacity—do not fall to be treated under the present head, but will be dealt with later on when considering instruments for measuring capacity. Testing sets for conductor and insulation resistances are, as a rule, not so elaborate in character as those for capacity, and can mostly be classed as portable testing sets, and it is these more particularly that will be dealt with at present.

For the measurement of the conductor resistance, say, of an electric light or power circuit, which is, as a rule, a very small quantity, the method most frequently adopted is by means of a Wheatstone's bridge arrangement, such as one of those already described. If the two ends of the portion of the circuit being tested are sufficiently near each other, the connections are made between the instrument and the circuit, and the measurement carried out in the usual way. If the ends of the circuit being measured are at such a distance from each other that this cannot be done, as in the case of a telegraph or telephone wire, the earth return is used in the manner illustrated in the last article, page 231, Fig. 43.

As manufacturers usually guarantee the conductivity of their conductors, and as any error in this respect soon makes itself evident, it is usual in ordinary electric light or power installations to either omit this test altogether, or to make it in a very rough way by means of what is known as a lineman's detector, or by some other equally simple method. But as perfect insulation is absolutely essential to the efficient working of any circuit, whether electric light, power, or traction, it is necessary to make the insulation test a very thorough and searching one.

Again, any gradual falling off in the conductivity of an electric light or power circuit, such as might be caused by bad contacts, weakening of imperfect joints, or electrolytic action, soon shows itself at the lamps or motors, but the insulation may go on deteriorating from day to day unnoticed, hence the necessity for repeated insulation tests being made. In the case of central stations, which usually involve an enormous network of wires, daily and even more frequent tests of the insulation are resorted to, and in ordinary installations the fire insurance companies advise that periodic insulation tests should be made and recorded.

As the insulation resistance of a circuit is, or at least ought to be, a very large quantity indeed, it has to be dealt with in an entirely different manner from conductor resistance. According to the rules drawn up by Mr. Musgrave Heaphy for the Phœnix Fire Office, for electric lighting circuits of the low-pressure type—that is, having a potential difference of not more than 500 volts—the whole insulation resistance should not be under the following:

Total number of lamps in installation.	Minimum insulation resistance of complete installation.
25 lamps	500,000 ohms.
50 ,,	250,000 ,,
100 ,,	125,000 ,,
500 ,,	25,000 ,,
1,000 ,,	12,500 ,,

The above figures are for continuous currents; for alternating currents twice the above resistances must be allowed for.

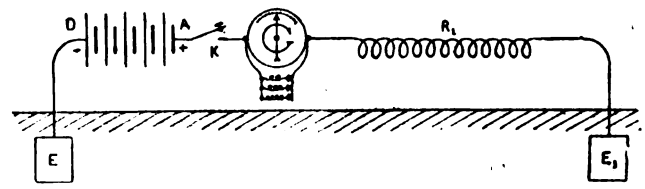

FIG. 44.—Measurement of Insulation Resistance—Known High Resistance in Circuit.

The method ordinarily adopted for the measurement of insulation resistance is a species of simple substitution method, and for this, as has already been shown, a Wheatstone's bridge is really not required. The manner in which this simple substitution method is employed is shown diagrammatically in Figs. 44 and 45, from which it will be seen that, with the exception that the earth is used as part of the circuit, the method is precisely the same as the one already described using the deflections of the galvanometer.

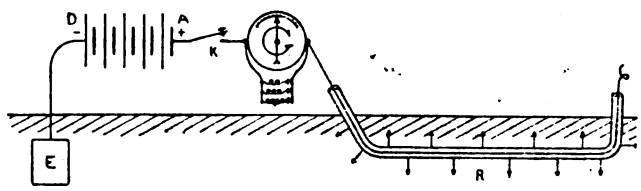

FIG. 45.—Measurement of Insulation Resistance—Insulation substituted for Known Resistance.

The operation consists essentially of two parts: first, determining the constant of the galvanometer with a very high known resistance, R_1, in circuit, Fig. 44; and second, finding the comparative deflection of the galvanometer with R, the insulation of the cable or system, in circuit instead, Fig. 45.

When dealing with such very high resistances, those of the galvanometer and battery being so small in comparison can be altogether neglected without sensible error, and the calculations are much simplified thereby. When the deflection obtained is too great, the galvanometer is shunted so as to bring it within the required limits. The effect of the shunt is to reduce the deflections in the ratio marked on it. Thus, if the deflection of the galvanometer when unshunted is 7·5 divisions, the deflection with the $\frac{1}{10}$ shunt will be 0·75 divisions, that is the same as would be obtained with the galvanometer unshunted and a resistance ten times as great. Thus the same deflection will be obtained with 10,000 ohms and the $\frac{1}{100}$ shunt as with 1,000,000 ohms—that is, one megohm—and the galvanometer unshunted.

From the two operations illustrated in Figs. 44 and 45, the value of the insulation resistance can be obtained as follows:

1. When the galvanometer is not shunted.

Let d_1 be the deflection with R_1 in circuit,
and d ,, ,, R ,,

Then $$R = R_1 \times \frac{d_1}{d}.$$

2. When the galvanometer is shunted.

Let $\frac{1}{s_1}$ be the value of the shunt
when the deflection d_1 is obtained,
and $\frac{1}{s}$ that ,, ,, d ,,

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Then $$R = R_1 \times \frac{d_1 s_1}{d s}.$$

As the resistance R and R_1 are both extremely high, the battery must be capable of developing a fairly large potential difference in order that a current of measurable dimensions may flow through the circuit. Usually from 40 to 50 volts are found to be sufficient, so that about 30 Leclanché or from 20 to 25 secondary cells will serve for any ordinary insulation test.

(To be continued.)

ELECTRIC LIGHT AND POWER.

BY ARTHUR F. GUY, ASSOC. MEM. INST. ELECTRICAL ENGINEERS.

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(Continued from page 257.)

THE ELECTROMOTOR.

The function of an electromotor is the inverse of that of a dynamo. The latter is a machine which receives mechanical power and yields electrical power; whereas the former is a machine that receives electrical power and yields mechanical power. A most simple and beautiful illustration showing the broad principle which governs the action of the electromotor was remarked by the writer, who happened to hold an incandescent lamp near the magnets of a dynamo at work in order to examine some defect. The filament of the lamp was drawn on one side so as to bend it, thus showing the pull that magnetism exerts in a conductor carrying a current. Of course, in this case the pull was visible, due to the delicate construction of the filament and the heavy current it was carrying (compared to its sectional area). In dealing with an active copper conductor no visible movement would be observed, although it would be subjected to a magnetic pull just the same.

Any well-constructed dynamo can be run as a motor, provided the same conditions be observed: if the dynamo be a constant-current machine, then it must be run from a constant-current circuit of same value; and if a constant-pressure machine, it must be run from a constant-pressure circuit of same or nearly same pressure as the dynamo is built for.

At the Crystal Palace Electrical Exhibition in 1892, a number of dynamos directly coupled up to steam-engines were converted into electromotors by supplying them with current, and so were made to put the engines into motion, providing an impressive and striking lesson respecting the wonderful adaptability of electricity. Owing to this feature of "reversibility," the construction of a motor is upon lines similar to those of a dynamo; and in most cases it would be difficult to say, without knowing, whether the machine, unmounted, was a dynamo or a motor, although, as a rule, motors are built heavier and with greater mechanical strength of parts than dynamos are.

Efficiency and Speed.—Before touching upon the various types of electromotors and their particular uses, the elementary principles which determine the efficiency and speed of motors will be explained, because the actions of a motor are rather peculiar to those who have no knowledge of this kind of machine.

The germ of the principle is the same as that governing a dynamo. In a dynamo, if a conductor be moved in a magnetic field so as to vary the lines that thread through the coil, an E.M.F. is generated in that coil, and hence a current when the circuit is completed; so that, given two things, movement and a magnetic field, the third, a current of electricity, is produced. In a motor, however, the two things given are a current of electricity and a magnetic field, and the third is produced—namely, movement of the current-carrying conductor; so that if a current of electricity is sent into a conductor or coil placed in a magnetic field, that coil will receive motion, and tend to set itself at right angles to the lines of force, if a number of coils symmetrically arranged in the form of an armature be inserted instead of the single coil, continuous motion would be imparted to the armature, as each coil tends to set itself at right angles to the magnetic field.

When a motor is at work it performs the double function of a dynamo and a motor, because the result of the armature of the motor being in motion induces a counter or back E.M.F. When the motor is standing still there is no back E.M.F., but it increases with the speed; and the faster the motor runs, the greater is the back E.M.F. that is generated. The current that the motor receives must be proportional to the difference between the E.M.F. of supply and the back E.M.F.; hence, upon starting a motor, it will absorb an enormous current, because there is no back E.M.F., and it is necessary to insert a resistance in series with the armature, and hence in series with the field coils when it is series wound, in order to reduce the current to a safe amount, otherwise it would burn up the armature. Putting E for the supply pressure and e for the back pressure generated by the armature of the motor, then the difference is $E - e$, and if R represents the total internal resistance of the motor, then the current that will flow will be $\frac{E-e}{R} = C$. To calculate the efficiency we must compare the electrical power or work put into the machine with the work given out by the machine—

the power absorbed $= C E$;
the power given out $= C e$;
hence the efficiency is $\frac{C e}{C E} = \frac{e}{E}$;

and is measured by the ratio between the pressure supplied and the back pressure generated. It is evident that when the motor is running as fast as it can possibly go, that will be when there is no load on it, and at the same time it will then absorb a minimum of power, because the back E.M.F. will then be at a maximum, and so the current flowing will be a minimum. On the other hand, when the motor is running very slowly, similar to when just starting a tramcar in motion, then it will have a very heavy load on it, and will draw a maximum amount of power, because the back E.M.F. will be almost at a minimum, and consequently the current will be at a maximum. The electromotor then adapts itself in a most fortunate way to its load, and on this account it is particularly suitable for propelling tramcars and the like, as it is just at the starting moment that an exceptionally great amount of power must be developed, in order to overcome the momentum or dead weight of the vehicle, and this is exactly what a motor will do; because when stationary a rush of current takes place, due to there being no back E.M.F., and so provides the necessary starting torque.

The useful work done by a motor was stated to be $C e$; and C was stated to be $\frac{E-e}{R}$, therefore substituting this last expression for C, we have work done $= \frac{e\,(E-e)}{R}$.

It is very easy to calculate the pull on the armature of any motor—only three things are required to be known. These are:

1. The density of the field.
2. The current in the armature.
3. The length of the armature.

Let the density be in lines per square centimetre;
„ „ current be amperes;
„ „ length of the armature be in centimetres;

then pull in dynes = density × current × length ÷ 10; the expression is divided by 10 because the current must be changed to C.G.S., or absolute units, which have a value of ten times the practical unit. Taking an example, suppose the armature of a motor carries 120 amperes, is 60cm. long, and that the field density is 11,000 lines per square centimetre; inserting values we have

$$\text{Pull in dynes} = \frac{11{,}000 \times 120 \times 60}{10} = 7{,}920{,}000.$$

A force of 981 dynes represent a weight of 1 gramme, and 454 grammes make 1lb., hence

$$\text{Pull} = \frac{7{,}920{,}000}{981 \times 454} = 18\text{lb.}$$

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Putting C for current in amperes;
L for length of armature in centimetres; and
D for density of lines per square centimetre;

we have $$\text{pull in pounds} = \frac{C \times L \times D}{4{\cdot}5 \times 10^6}.$$

Direct-current motors may be divided into two distinct classes, just as dynamos are divided into classes. These two are constant-pressure motors and constant-current motors.

Constant-Pressure Motor.—Motors made to run from a constant pressure source of electric supply can be either shunt or series wound. Shunt motors have several features in distinction to series-wound motors. They will run at very nearly a constant speed, irrespective of what the load may be; and if the field be compounded, then they will run at a perfectly regular speed. In dynamos it is necessary to give the brushes a forward "lead" in proportion to the load or number of lights supplied, but in motors of all classes the opposite holds good—that is, it is necessary to give the brushes a backward "lead"; and the greater the amount of work which a shunt-wound motor does the greater must be this back "lead," so that when there is no load on the machine the brushes will occupy a normal position. It is necessary to have a starting resistance in series with the armature of all motors, whether shunt or series, because, if not, the armature would produce a dead short-circuit. Some motors have their starting switch so arranged that when the machine has got up a fair speed the starting resistance is shifted from the armature coils into the shunt or field coils so as to strengthen the armature current and weaken the field.

In a series-wound motor on a constant-pressure circuit, the pull on the armature bars is in proportion to the amount of current flowing, and since the current is greatest at the starting moment, hence the maximum pull is exerted by the motor at that moment, because there is practically no speed or motion of the motor, and so there can be no back pressure generated. The field of the series motor is not constant like that of a shunt-wound motor. In a shunt motor, the current passing round the field coils is constant, and so at the moment of starting there is a heavy current only in the armature, the strength of the field remaining constant whether at the start or at full speed; but in a series motor, the same current passes through the field coils as passes through the armature. Consequently, when a series motor is started, there is a heavy rush of current for a few seconds through both field and armature coils; hence the statical pull is enormously increased. In addition, a series motor does not run at a constant speed. Owing to these features, it is eminently suitable for traction work, and is almost universally employed for that purpose. Like the shunt motor, it is necessary to insert a starting resistance in the circuit of the motor; none is required in the field coils, because they are in series with the armature. So the starting resistance, the field coils, and the armature are all put in series, making one circuit; then when the motor has got up sufficient speed to generate a back pressure, the starting resistance can be taken out, if requisite. A caution might here be made that the load of a series motor should never be thrown off when the current is on or the motor in circuit, otherwise it will act like an engine without governors: it will increase its speed to a dangerous extent.

Compound-wound motors are not of much use, and are not so safe to run as a plain shunt-wound motor; when they get overloaded the action of the series coil interferes with that of the shunt.

In dealing with motors, very careful distinction must be made between the *maximum efficiency* of a motor and its *maximum work*. It was explained that the faster a motor runs the nearer does the back pressure generated approach to the value of the supply pressure; and since the current flowing is proportional to the difference of these two pressures, it is clear that when the motor is running at its maximum speed there is a minimum of current flowing, and the power absorbed is also a minimum. If it were possible for the motor to run so fast that it would generate a back pressure equal to the supply pressure, then no current would flow, and therefore no power would be absorbed, but the fact of running proves that some small amount of power *must* be absorbed in order to overcome the frictional resistance of the machine; hence the limit of the speed is such that the back pressure is slightly below the supply pressure. The motor is then doing no external work—only running idle—and the efficiency is then at a maximum—perhaps 98 per cent. Taking the other extreme view of the case, let the motor be so overloaded that it cannot move; there will be no back pressure, but a heavy current will flow, limited to a safe amount by resistances. Beyond the heating effect of current, no power is absorbed, and again there is no external work done by the motor, because it is stationary. The efficiency in this case is at a minimum; it receives a large amount of power, absorbed in heating the coils, and gives none out. Hence, when standing still and running at its maximum speed, no useful external work is done. Therefore all external work must be done by the motor at speeds between these two conditions. By experiment it is found that the maximum amount of external work is done by the motor, when the motor runs at such a speed that the current flowing when the motor is stationary is reduced to one-half of its value—that is to say, the maximum work is done when the motor runs at a speed to develop a back pressure equal to one-half that of the supply pressure, so that signifies that when a motor is doing its greatest amount of work, it is working at an efficiency of only 50 per cent., and that the efficiency of a motor varies inversely to the amount of work it does, within certain limits.

(To be continued.)

THE SHEFFIELD ELECTRIC LIGHT AND POWER STATION.

THE STARTING OF THE NEW STATION.

The ceremony of starting the plant in the new central station of the Sheffield Electric Light and Power Company, Limited, took place on Saturday last in the presence of the members of the Corporation and the directors of the company. Alderman Franklin, chairman of the company, presided, and the current was switched on to the underground mains by the mayor (Alderman Foster).

Mr. W. Johnson, the courteous engineer to the company, gave an explanatory statement previous to the current being passed into the distributing circuits. From his remarks we learned that the present electric light station has been built over the site of a pioneer station of arc lighting plant started by Mr. John Tasker in 1885-6. In 1888 the pioneer station was acquired by the late Sheffield Telephone Exchange and Electric Light Company, but at that time the company was extremely busy with telephone work, and was unable to give as much attention to electric lighting as its importance warranted. Still, the possibilities and prospects of incandescent electric lighting were so obviously promising that when it was first endeavoured to deal with alternating-current distribution over scattered areas, one of the earliest made machines was laid down in Sheffield, and the system was given a fair trial with overhead cables. Sudden and unexpected extinction of the lights from various causes frequently took place, but every failure of the light was a distinct and valuable object-lesson. Electrical engineers were being educated day by day, improvements followed in rapid succession, and electric lighting history was written in large characters. The public gave the electric light a hearty welcome, and the company, with every confidence in the alternating-current system and in the electrical and mechanical appliances manufactured by the Brush Electrical Company, laid down such additional plant from time to time as was necessary to meet the growing requirements. In 1892 the company disposed of its telephone business, and changed its name to the Sheffield Electric Light and Power Company, Limited, and with the full sanction of the Corporation of Sheffield at once obtained statutory powers to supply electrical energy within the municipal boundary of Sheffield. These powers made it compulsory upon the company to remove the overhead mains, and to lay down

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electric light cables as was necessary to supply current within a district in the centre of the town and to give the public a constant supply. It was only by completely remodelling the power station that the company could meet its obligations to the Board of Trade and to the public. Therefore, at the beginning of 1893, the company undertook the work of rebuilding a new and much larger station over the then existing station; the laying of underground mains in the compulsory area; the erection of new boilers in lieu of the Lancashire boilers hitherto in use; the rearrangement of all the engines, machinery, and steam service in the new station; the erection of new machinery; the transfer of the current from the overhead cables to underground cables; and the provision for new consumers. This work had to be done without stopping the supply of current, and it has been accomplished without hitch or serious accident. Hitherto the extension and use of electric light in Sheffield have been restricted only by the inability of the company to supply current, and the completion of the work within the compulsory area is but a step in the direction of enabling the company to greatly extend its operations and to enlarge its borders. To supply current from house to house in the residential districts has always been one of the chief aims of the company, and from those districts has already begun a demand that in its growth will later on tax the capacity of the new premises to meet. Of course, in providing for the future, there must be a limit to the extent of buildings and the provision of floor space for engines and dynamos; but the floor space now available for machinery will enable the company to carry on a large and important work. Mr. J. D. Webster has been the architect for the new station, Messrs. W. and A. Forsdike were the contractors for the buildings, and Messrs. Tasker, Sons, and Co. carried out the steam and water service.

Alderman FRANKLIN, chairman of the company, having welcomed the visitors, the MAYOR addressed the assembly and then switched on the current. Subsequently, the directors of the company entertained the members of the Corporation at dinner at the Masonic Hall. The toast of the evening, "The Sheffield Electric Light and Power Company, Limited," was proposed by Mr. J. D. LEADER and responded to by Alderman FRANKLIN, whilst that of "The Electrical Industries," given by Alderman W. J. CLEGG, was acknowledged by Messrs. RAWORTH, MORDEY, and BINSWANGER.

A public demonstration of cooking and heating by electricity was given at the central station on Monday and Tuesday by the General Electric Company, and on Wednesday evening the staff dinner of the officials and employés of the company took place.

THE BOILER-HOUSE.

Proceeding now to describe the central station, it is noteworthy that ample space is provided for future extensions of the plant. This will be readily understood when it is mentioned that whereas the present capacity of the station is 10,500 incandescent lamps, there is accommodation for further plant capable of bringing the total output up to something like 30,000 lamps. The station is erected in three spans, covering a superficial area of 2,060 yards. The boiler-house, which is arranged under one span, is 112ft. long by 35ft. wide, and occupies a lower level than the roadway. Bunkers have been excavated under the roadway, and into these the coal is shot immediately in front of the boilers. A free supply of water is taken from a large dam supplied by the River Sheaf (Sheaf-field). The boiler-house contains five Babcock and Wilcox boilers, each capable of evaporating 5,000lb. of water per hour. These boilers work at 120lb., and two of them are fitted with automatic stokers. Over the boiler-house is erected a tank holding a reserve of 20,000 gallons of water, and the tank can be supplied from the dam or from the town mains. Duplex wall pumps (one spare) deal with the boiler feed-water, which is passed through a meter in order that the evaporative efficiency of the boilers may be ascertained. The mechanical stokers and the scrapers of the water heater are operated by a small marine engine. The blow-off water from the boilers and all steam-pipe drainage is cooled before being allowed to leave the station.

The arc lighting plant, which has been in use for some years, is arranged at the other end of the boiler-house. This comprises a horizontal compound jet condensing-engine, belted to a countershaft supplying power to three Thomson-Houston arc lighting machines. Each machine will maintain 50 10-ampere lamps in series. This arc lighting plant remains for the present in the position it first occupied, and is the only machinery that has not been disturbed. When necessary, this plant will be transferred to another part of the station, and will be more compactly arranged.

THE ENGINE AND DYNAMO ROOM.

Two spacious and lofty spans, supported in the middle by metal stanchions, have been reserved for the engines and dynamos for incandescent lighting. The plant at present in use occupies only a part of one of these spans, so that there is abundant floor space for future developments. The whole space is light and airy, and the walls are lined with white bricks. At present there are laid down four vertical Brush engines with Mordey alternators. One alternator carries an exciter on its shaft, and there are two separate exciters direct coupled to Brush engines. The alternators comprise two Mordey machines of 100 kilowatts, one of 50 kilowatts and one of 37½ kilowatts, the current being generated at 2,000 volts. The two separate exciters are of the Victoria type, each of 6½ kilowatts. All the engines and dynamos stand on substantial ashlar foundations. Foundations have also been provided for an additional 500-h.p. plant, which is anticipated will immediately be required to meet the coming demand for current. All the alternators are rope-driven.

Duplicate steam-mains have been fixed over the boilers. These mains are 15in. internal diameter, and of wrought steel lap-welded. The pipes leading from the steam-mains to the engines are also of wrought steel with flanges accurately turned, and the pipes have been tested to a pressure of 600lb. per square inch. The bends of these pipes are of copper. Expansion has been suitably provided for, and the steam-mains are drained through well pipes and steam-traps to ensure dry steam. Hopkinson's high-pressure parallel slide valves have been used throughout. All the engines exhaust into a main exhaust trunk, 12in. diameter, to which is attached an independent condenser of the Worthington pumping-engine type, and a steady vacuum is maintained. Any engine may be shut off from the exhaust trunk, and relief valves are provided for the engines to exhaust into the atmosphere if required, or part of the engines can run on the condenser whilst the others are discharging into atmosphere. The discharge water from the condenser falls under the wall pumps in the boiler-house, and is thence forced through the water-heater, which is a Green economiser, into the boilers. All the drain-pipes in the engine-house are laid in concrete channels covered with chequered floor-plates, and the engines and alternators are provided with polished guard-rails. The oil from all the engines is drained into a reservoir, and is then pumped into filters to be used again. A 10-ton travelling crane, made by Messrs. Appleby and Co., is thrown across one of the spans, and brackets have been cast on the metal stanchions supporting the middle span for another crane. In the engine-house there is an office and testing-room, a meter-testing room, storeroom, workshop, messroom, and lavatories; but during the course of future extensions some of these may have to be removed to another portion of the company's land that has not yet been built upon. All the floors are fireproof.

PARALLEL RUNNING.

Such arrangements have been made that only parallel running is possible when more than one machine is in use. All the alternator fields are excited in parallel. Each exciter carries its own automatic switching gear and electrical governor. All the alternators feed into one pair of 'bus mains. Each alternator has its own synchronising pillar. Each synchronising pillar has its own complete switching gear, consisting of one field switch, one synchroniser and switch, and one double-pole main water switch, together with the necessary voltmeter, ammeter, and fuses. The switches are interlocking, and can only be moved in their proper order, thereby rendering accidents from inadvertence

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on the part of the attendant impossible, and the whole operation necessary to secure synchronism and parallelism is practically reduced to a mechanical process. The pillars are built up of sectional castings. The electrical requirements are excellently provided for.

The current leaving the station is passed through recording apparatus, arranged in a special apartment, for the purpose of obtaining a permanent chart of primary volts, the apparent power sent out of the station at any instant, and the total true watts sent out in any time. These records will, amongst other things, by comparison with the readings of consumers' meters, enable the company to ascertain the amount of loss that may take place in transmission and transformation. The recording-room contains a Thomson primary wattmeter, registering the total output of the station; a Mengarini chart-reading voltmeter, an Ayrton and Mather astatic voltmeter, and three main ammeters, of 20, 150, and 300 amperes respectively, supplied by Messrs. Nalder Bros.

The 'bus mains are taken from the recording-room to the distributing-board, where the various feeder circuits, of which there are four, are controlled by massive aluminium single-pole lever switches. Each pair of feeders has its own ammeter and fuses. A rheostat fixed on the distributing-board controls the excitation, and consequently the primary volts, and here also are terminated the potential leads from the various transformer centres.

The Mains.

The primary circuits are concentric, of the Glover type, insulated with vulcanised rubber, and drawn into 3in. cast-iron pipes. The arc light circuits are concentric, and of paper insulation, lead-covered. The secondary circuits are insulated on Callender's bitumen system, and are laid in iron troughs and filled in with solid bitumen. Seven miles of conductor have been laid in the compulsory area, together with seven miles of spare pipes to meet future demands. The company have also laid down pipes intended for the reception of cables for the residential districts of Ranmoor and Broomhill, as far as the Monolith, so that the distance between there and the suburbs will be quickly covered.

Transformation and Distribution.

The system authorised for use in Sheffield is a high-pressure alternating-current supply partly to converting stations from which a low-pressure supply at constant pressure is given to consumers, and partly, where consumers' premises are scattered, to transformers installed upon consumers' premises. Seven transformer-chambers for reducing the current from 2,000 volts to 100 volts have been sunk below the streets, although there will be nine of them in use in the compulsory area. The transformers, which are of the Mordey type, are joined in parallel between the feeder mains, and the potentials are evenly distributed throughout the secondary network. Hitherto separate transformers have been installed upon consumers' premises, and the removal of those transformers into the chambers has brought about a remarkable decrease in the magnetising current.

The charge made for current is at the rate of 6d. per Board of Trade unit. The company have a showroom for electric light fittings in Church-street for the inspection of intending consumers.

At the present time the company have 8,812 30-watt lamps connected to the mains. The design and general arrangement of the station reflects credit upon all concerned in the matter.

COMPARATIVE VALUE OF CERTAIN WIRING PLANS AND SOME WIRING POINTERS.

BY E. P. ROBERTS.

The statement is frequently made that the arrangement of wires as shown in Fig. 8 gives the same potential at any point of the loop circuit, and that therefore it is the best arrangement, when considered from the standpoint of the lamp. That this is not a fact has, however, been shown, and that it is only true when the cross-section of the wire is made proportional to the current, as in Fig. 9, has also been demonstrated, although many "experts" are not acquainted with the fact. The writer has argued the case with a well-known and really first-class "expert," who, as an installer of apparatus, is one of the best in the country, and who claimed, and still claims, that Fig. 8 not only gives perfect distribution at any load, but takes the least possible copper for a given loss, and that its only disadvantage is that it is not convenient to test out same in case of trouble; also that the "theory" which can obtain the results tabulated below is "off," or the writer is. As the "theory" is Ohm's law, the writer suggested that the only error possible is in the application. The expert stated that he had erected a system of the character shown by Fig. 8, and used two-thirds the copper required by Fig. 6, and a voltmeter showed that his statement was correct, and he did not care for any figures; he went by facts. This controversy furnished much food for thought, and could easily be made the text for an article; it is now only given trusting that it will excite the reader to sufficient interest in the table to work out the results, and then, if he is a believer in the correctness of Ohm's law, he can judge for himself.

The method used for the calculation is the "drop of potential." In each case the same size wire is considered, and the R and C flow being known, the drop calculated. The C for each lamp is taken as constant, which, though not exactly correct, is sufficiently so. If the reader prefer, he can consider the translating devices not as lamps, but of wire of constant R. The error, when lamps are considered, is towards compensation, as increased potential at any point increases C and lamp R decreases, but increased C cuts down potential. This must not be confused with distribution; the action is merely partly compensating for varying R with C, but the increased C exists and the lamp is being strained—the latter is not being compensated.

It may be well to premise the working out of the examples by some general statements which contain truths often lost sight of. All electrical men are now acquainted with Thomson's law as to the economical size of conductors. Many understand how to use it; others, from lack of knowledge of how to determine the variable factors, consider it as of no practical bearing, but the point now desired to elucidate is that Thomson's law is based on the R of the circuit, being based on the energy lost, and that for a given weight of copper the energy wasted for a given amount used depends upon the distribution of the copper, and that by knowledge and careful planning one man can get far better results as to distribution and loss of energy than another, who either does not know or care, or, knowing, will not take the time. Possibly the last man is not paid sufficiently; possibly the more material going in the better for him; possibly he considers it unnecessary labour, because it will never be appreciated.

Case first: The least amount of energy is wasted (commercially speaking) if the loss of potential be proportional to the lineal feet travelled.

If, in Fig. 7, we have four conductors of 10 B. & S. (one ohm per M. feet) leading to a point 500ft. distant and 10 amperes flow, and we connect up, as shown in *a*, *b*, *c* and *d*, we find that the drop and losses are as follows:

	A.		B.		C.		D.	
	P.D.	Watts.	P.D.	Watts.	P.D.	Watts.	P.D.	Watts.
1-2	1·25	—	2·5	—	·83	—	·83	—
2-3	1·25	—	2·5	—	2·50	—	2·50	—
4-5	1·25	—	·88	—	1·25	—	2·50	—
5-6	1·25	—	·88	—	1·25	—	·83	—
1-3	2·50	—	5·	—	3·33	—	3·38	—
4-6	2·50	—	1·66	—	2·5	—	3·38	—
Total	15·	50·	6·66	66·	5·83	58·3	6·66	66·6

Evidently a certain total number of pounds of copper can be used to better advantage in *a* than in *b*, *c*, or *d*, and it is not an equivalent to run one size of wire a certain distance and piece out with another size, even if the total pounds be the same.

For the sake of simplifying calculations, No. 10 wire, and multiples thereof, is used in all the examples. Another way would be to consider the R per millimetre foot, and it is a simpler method for those who are used to using the same.

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Another case: Fig. 2, *a* and *b*:

	Loss in 1-2 and 4-5.			Loss in 2-3 and 5-6.			Total.	
	Ohms.	C.	P.D.	Watts.	Ohms.	C.	P.D.	Watts.	P.D.	Watts.
A ...	·25	10	2·5	25	·508	5	2·50	12·50	5	37·50
B ...	·33⅓	10	3·3⅓	33⅓	·33⅓	5	1·66⅔	8·30	5	41·66

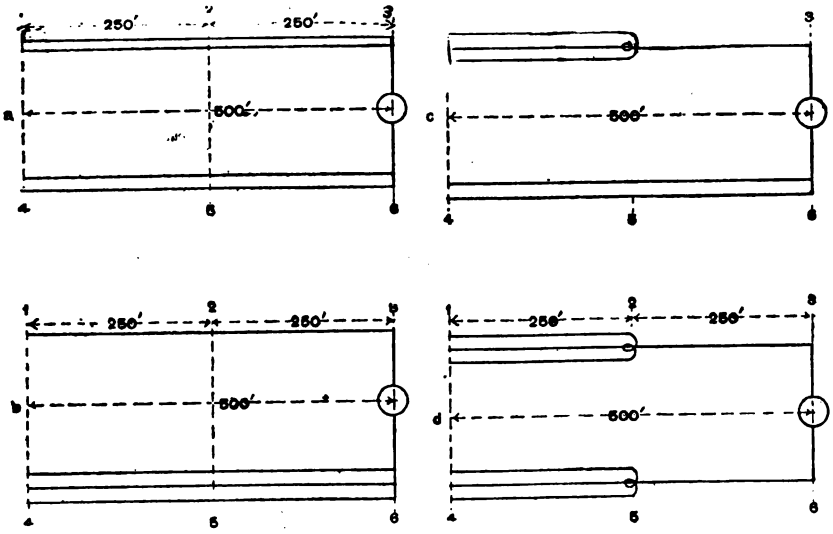


FIG. 1.

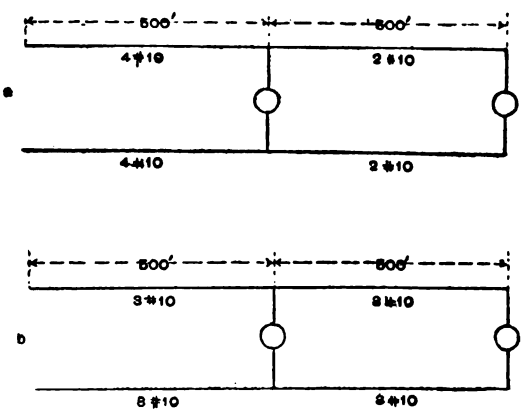
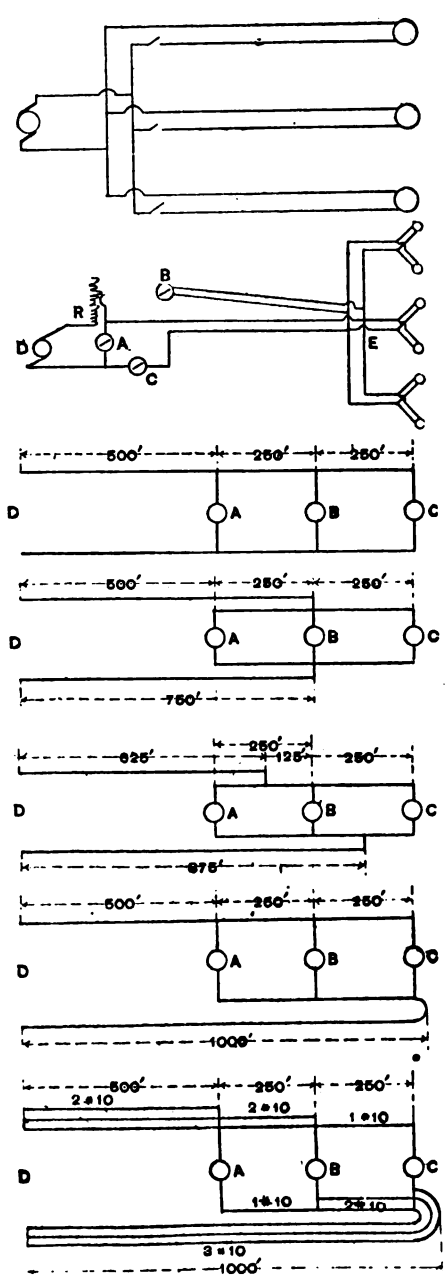


FIG. 2.



FIGS. 3, 4, 5, 6, 7, 8 AND 9.

Note that although the drop from one end to the other is the same, there is, nevertheless, more energy wasted in *b* than in *a*, but also note that if incandescent lamps be the translating device used, *b* would be better than *a*, because of better regulation. This does not affect the principles as to the least amount of energy lost, but shows that there may be more than one principle to consider

It is generally known that the only way to obtain perfect regulation is to maintain constant P.D. at the dynamo, and to run a separate circuit to each set of devices, all of which must be "on" or "off," Fig. 3. As this is generally impracticable, an effort is made to maintain constant P.D. as near the lamps as possible (see Fig. 4), where D represents a dynamo, R a resistance, so that P.D. at E can be controlled; it may be controlled in other ways; B a voltmeter to indicate P.D. at E; a voltmeter, A, and ammeter, C, may be used, and the P.D. at E kept constant by knowing R from D to E and using Ohm's law. It may, however, be impossible to bring E very near the lamps, or the plant may be an isolated one, in which latter case compound-wound machines are often depended upon for keeping the P.D. at the dynamo proportional to the current, and an effort be made (though probably it is not, and often cannot be made) to have circuits so divided as to all change load in about the same ratio. Whether there be a constant potential point at the dynamo, at some point along the leading wires, or at some lamp, will only vary the conditions and results obtained, but the general deductions obtained from considering the following cases remain true.

Figs. 5, 6, 7, 8, and 9 show different methods of wiring for translating devices, A, B, C. Each device to take 10 amperes.

1. If each is to have the same size wire throughout, consider No. 10, because of convenience, and use two wires for a conductor in Figs. 5, 6, 7, and 8, and in Fig. 9 taper off, as shown, making cross-sections proportional to C.

If potential be kept constant at 100 volts at B and full load, then

	5	6	7	8	9
P.D. at B	100·0	100·0	100·000	100·00	100·0
P.D. at A	105·0	97·5	99·375	101·25	100·0
P.D. at C	97·5	97·5	99·375	101·25	100·0
P.D. at D	120·0	122·5	125·000	127·50	121·5
Total feet wire	4,000·0	5,000·0	5,000·000	5,000·00	6,000·0

If potential be kept constant 100 volts at B, and B be cut down to half-load, A be fully loaded, and C one-quarter loaded, then

	5	6	7	8	9
P.D. at B	100·00	100·00	100·00	100·00	100·00
P.D. at A	101·87	97·50	98·59	100·31	98·44
P.D. at C	99·37	99·37	100·47	101·56	101·25
P.D. at D	110·62	113·12	114·53	115·94	111·56

If potential be kept as before at B, and A be at one-half load, and B at one-quarter load and C at full load, then

	5	6	7	8	9
P.D. at B	100·00	100·00	100·00	100·00	100·00
P.D. at A	103·12	98·75	99·84	100·94	100·31
P.D. at C	97·50	97·50	98·59	99·69	98·44
P.D. at D	111·87	112·12	114·37	115·62	111·25

Many other conditions might be assumed, such as maintaining the P.D. at D constant, and that necessary for full

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load, which, if D be the feeder end, is often done in central stations; or making P.D. at D proportional to C, which is the case when using an over-compound dynamo, and taking D as the dynamo; but enough has been stated to show that No. 7 is better than No. 8, not only in weight of copper and energy lost, but in regulation at full load, and for most variations under varying loads.

ECONOMY OF INCANDESCENT LAMPS.

BY W. STUART-SMITH.

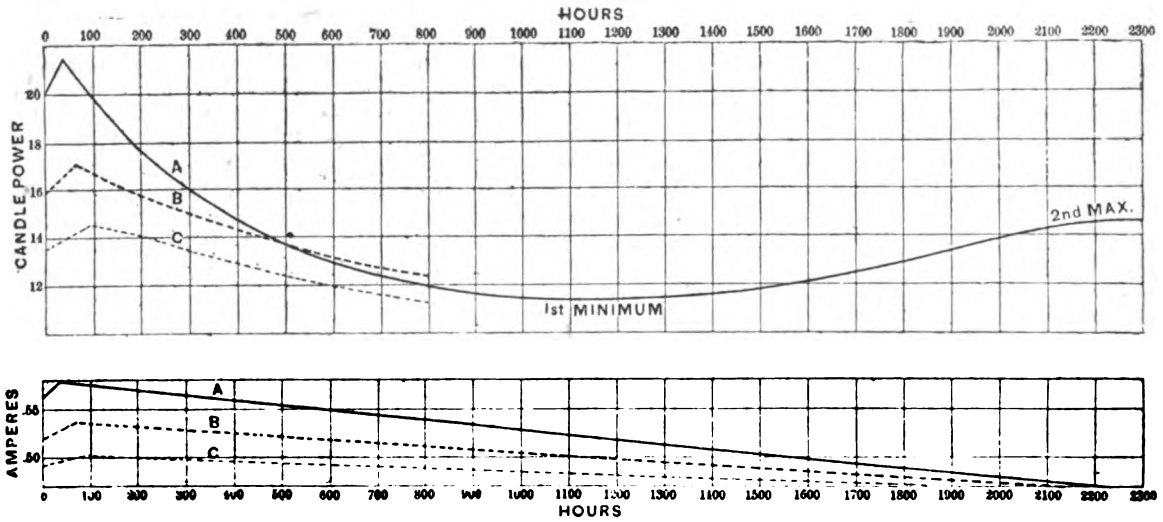
Why does the economy of incandescent lamps fall so rapidly after they have been burning a few hours? Every electrician has asked himself and others this question, and a vast amount of time has been spent and expense incurred trying to find out. The result is that every well-informed electrician will answer "that the filament undergoes a change in structure that seems to decrease its illuminating power." The resistance of the filament and current taken vary but little, while the light-giving powers fall through a wide range. A decrease in the illuminating power would seem to indicate a decreased temperature, which, with a nearly constant current, could only be caused by an increase in the specific heat produced by a structural change, and this explanation is the generally accepted one. It is the purpose of this article to show that such an assumption is entirely unnecessary, and that a very simple and familiar phenomenon is sufficient to account for the fall of efficiency.

After passing through a maximum the current falls slowly and steadily, the curve being very nearly a straight line. This is, no doubt, caused by the resistance increasing as the filament becomes smaller, through vaporisation. As the curve is so nearly a straight line, the current decreases exactly in proportion to the volume of the filament, and the temperature should remain constant, unless there is an increase in the specific heat.

A further examination of the candle-power and efficiency curves will show that the slope becomes less and less with time, and if continued they would probably reach the horizontal, pass through a point of minimum value, and then rise again to another maximum of less value than the first. This last point is not evident from the curves, but, I think, can be shown.

The current curves, if prolonged, will be found to intersect nearly in a point. If this is not accidental, it means that point when the filaments become so attenuated through vaporisation that they become practically of no section. In practice they will break before reaching this point.

In my article on "Blackening of Incandescent Lamp Bulbs" (the *Electrical World*, November 11, 1893) I suggested that the carbon filaments are not homogeneous, and that some portions volatilised more rapidly than others, and if this is true (as seems probable), a microscopic examination of filaments which have burned for some time will show them to have very irregular surfaces, being pitted and scored in every direction. During the early stages of illumination this would not have a deleterious effect, but,



INCANDESCENT LAMP EFFICIENCY CURVES.

Referring to Lieutenant Eyre's article on incandescent lamp economy (the *Electrical World*, January 13, 1894), we see there three sets of curves given, and first it is seen that all three sets of curves rise rapidly for periods varying from 40 to 100 hours, depending upon the original candle-power of the lamps. A maximum is soon reached, after which all the curves fall away.

The increase of the current at once indicates a decreased resistance, and this is probably caused by the filament becoming more dense under the action of the heat, just as a piece of porcelain will contract permanently if raised to a temperature higher than that at which it was fired. Although the filament may not be any hotter than it was at some points in its manufacture, yet the temperature is maintained much longer, and thus may have the effect of a higher temperature maintained for a short time.

The curves are shown as rising in a straight line from the origin to a maximum; it is probable that greater care in plotting would show a concave portion near the origin, followed by a point of contrary flexure, and a convex portion passing through a horizontal at a maximum, then another point of contrary flexure, followed by a curve of large radius. The candle-power curve rises much more rapidly from the origin than the current, due, of course, to the fact that at the higher temperature produced by the extra current a larger percentage of the total energy consists of light-giving rays.

on the contrary, might add to the illuminating power by increasing the virtual surface, just as roughening the surface of a stove is beneficial by increasing the radiating surface. If this is true, then part of the increased illumination near the origin is due to this and part to the increased current, and the effects would be hard to separate. In any case, the effect of pitting would be small and would not prevent the point of maximum light-giving power coinciding with the point of maximum current. After a time, however, a totally different effect will occur. As the pittings and scorings increase in depth a point will be reached when the light emanating from the crests and hollows will be half a wave-length apart, and when this occurs part of the light will be destroyed, with the result that the total illumination will begin to decrease. At first but few points will have the requisite depth for interference, and the diminution of light will be small, but as time goes on the number will greatly increase and interference will take place over the whole surface, and the effect will be greatly diminished illumination, due to the virtual decrease of illuminating surface. The effect will be the same as interference in the case of gratings, opals, Newton's rings, etc. Gratings, opals, etc., produce colour effects, and it may be asked why, if this effect is the same, colours are not also produced. The answer is simple: gratings, etc., are regular, and the results are even distribution of interference with consequent colour effects, but

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in the case of the filaments, owing to non-homogeneity, the pittings and scorings will be very irregular, and the result will be that colour effects from adjacent portions will be interspersed and the resulting effect will still be white light, though it will have less intensity than originally, on account of a portion of the light having been destroyed. If some colour predominated, it would not show distinctly, but would be diffused throughout the mass of the illumination and give a general tint to the light, and it is well known that the colour does change, becoming more red. Probably it also goes through other tints, but they are less noticeable, as the carbon deposit on the glass tends to absorb them and leave the red, which have the longest waves.

According to this view, the intensity of the illumination of every point of the filament remains the same as before, but the combined effect is less, owing to partial destruction just off the surface. Similar reasoning shows that the carbon is actually heated to the same temperature at all time during its life, but if the radiated heat should be measured it would be found to decrease, owing to interference as before. All this, of course, is independent of the effect of the carbon deposited on the glass. That is a mechanical interference, and has nothing to do with the light-giving power of the filament. It is the filament which is being considered here, and not the lamp as a whole.

It can now be seen why the slope of the curves decrease and approach a horizontal; in fact, why they must reach a minimum value, and then rise again to another maximum, to be followed by a second minimum, etc. As the pits and scores grow there comes a time when a maximum number have the right depth and size to produce a maximum interference, and at this point the virtual surface and consequent illumination will be a minimum, and the candle-power and efficiency curves will both reach a horizontal. Beyond this point interference begins to decrease and the curves begin to rise, but at a less angle than that at which descent was made, because as the filament wears away the current decreases. After a time the pits and scores will reach such a size that the virtual surface will be nearly that of the actual area of the carbon, and the candle power and illuminating curves will again pass through a maximum. This, however, will be less than before, because now the actual surface of the filament is less than originally, on account of the vaporisation which has taken place. Theoretically, there should be a series of waves, similar to sine curves, but having the part below the axis larger than the part above. They would be drawn about an oblique axis, to which they would tend to approach as the filament wore away. After the first wave they would tend to become complex, because the pits would then have considerable size and other pits would form within them and the effects would be superimposed. This recurrence of waves assumes, of course, that the carbons had so much section that they could stand the excessive scoring and pitting without breaking. In practice with lamps of high candle-power and stout carbons, the second maximum might be reached, but probably nothing beyond that, and even this might not be noticed, on account of the blackening of the globes.

High candle-power lamps would feel the effect of this scoring and pitting sooner, because, owing to the greater size and consequent greater want of homogeneity, the pitting and scoring would be more rapid, and thus the more rapid falling off of illumination in high candle-power lamps is accounted for. It is even possible that with such lamps several maxima and minima might occur during the life, though, owing to the pitting within the pits, as above explained, and the consequent superimposed curves, a steady illumination might take place, or, rather, the oblique axis might be reached by the candle-power curve. It could not become permanently horizontal, because the filament wears away and the current falls constantly. However, when the oblique axis was practically reached, the efficiency curve would become a horizontal line or a curve waving slightly above and below a horizontal. When this occurs, the efficiency should be nearly the original value because, though the illumination would be less, it would be practically proportional to the current.

The explanation given accounts for all the eccentricities of filaments, and points out the line to be followed in order to produce lamps that shall maintain high efficiency throughout their life.

The original cause is want of homogeneity, and probably this can never be overcome so long as organic, structural material is used for making filaments. It showed that a non-structural amorphous mass should be used as original material, and this must be chemically produced in such a manner as to be absolutely homogeneous. This being the case, the filaments will wear away evenly without pitting, and though the candle-power will fall steadily as the filament wears away, it will still remain proportional to the current, and the efficiency will retain a constant value equal to the maximum near the origin.

Owing to the fact that experiments are made on lamps as a whole, the fall of efficiency and candle-power observed are the combined effects of the lessened efficiency of the filament and increased absorption by the deposit on the globe. This absorption not only causes the curves to fall to a lower value and gives the oblique axis a greater inclination than it would otherwise have, but it also causes the minimum values of these curves to be reached at a later period, or the minima of the lamp are both lower and later than the minima of the filament.

Also, even if the filament had so much stock that after a time equilibrium in interference might be attained and the efficiency curve of the filament become a horizontal line, the continually increasing deposit would cause the curve for the lamp to slope downward.

FAULTS INCIDENT TO THE PROTECTION OF LIGHTING AND POWER CIRCUITS.

Mr. W. E. Harrington read before the recent meeting of the National Electric Light Association at Washington a paper on the above subject, of which he and Mr. L. Stanley were joint authors, drawing attention to the various causes affecting the reliability of fuses and magnetic cut-outs. The defects in fuses are enumerated as follows:

(1) Lack of uniformity in proportioning and mixing the constituent alloys of the fuse; also in the methods of drawing the wire to a uniform geometric cross-section, and in preparing the fuse for the market. (2) Lack of uniformity, in practice, in the actual placing of the fuse in the following particulars: (*a*) length of fuse for a given service; (*b*) mass of the terminals used; (*c*) position of fuse as to whether it be vertical or horizontal; (*d*) environment, whether it be held in suspension, between terminals, or is allowed to lie along its entire length upon a mass of heat-radiating material, and whether it be open to the air or enclosed in a chamber. (3) Deterioration caused by (*a*) recurring abnormal currents; (*b*) oxidation from various causes; (*c*) disintegration from local voltaic action. 4. Impairment of contact at terminals due to loosening of the clamps from temperature expansions and contractions, or to mechanical or electrical causes. (5) The "Peltier" effect. (6) The abuse of acceptable fusing devices by substituting for the metals designed to be used in them others that are unsuitable. (7) Time element. Practice has demonstrated that fuses rarely, if ever, "blow" in time to accomplish the object for which they are placed in circuit. There is also a wide range of uncertainty as to the constancy of this period of time for any given fuse. (8) Capacity of the ordinary fuse wire to pass current far in excess of its rated blowing capacity for a period of time sufficient, in a majority of cases, to cause damage to some portion of the circuit. The conclusion of the authors is that the fuse-wire cut-out is not only an absolute failure, but actually dangerous.

Magnetic cut-outs are divided into two classes: first, a long-throw knife-blade switch operated to open by a trip actuated by the armature of an electromagnet; and second, a device for preventing or for blowing out the arc formed at the switch jaws by the breaking of the circuit. The principal point of difference in any two magnetic cut-outs of the present day is the methods adopted to overcome the destructive effect of the arc, which are the auxiliary break method and the electro-magnetic blow-out method. Of these the first is criticised on account of the carbon plates or pencils employed, which are not only fragile and quickly destroyed by an abnormal current, but generate a highly conductive gas, which may not only cause damage in the circuit in which it is evolved, but also to neighbouring circuits on the switchboard. Besides, the auxiliary circuit is not competent to carry its proportion of an abnormal current, with the consequence that both the bridge and switch plates may be fused before the circuit is opened. Other defects are pointed out, but the conclusion is reached that, with all of their faults, magnetic cut-outs are superior to fuses.

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THE
ELECTRICAL ENGINEER.

Published every Friday.
Price Threepence; Post Free, Threepence Halfpenny.
Editorial and Publishing Offices:
139-140, SALISBURY COURT, FLEET STREET,
LONDON, E.C.

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TO CORRESPONDENTS.

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DIRECT OR ALTERNATE.

There is a never-ending controversy as to the system best adapted for any central station. At the present time the advocates for a high-pressure alternating system generally manage to prove that the system is the one best adapted to that district. We cannot expect business men to trouble much about future years. They have enough to do to obtain orders sufficient to keep works going to-day. It is not, then, to them that we must look for guidance. Shareholders rightly say, sell what you have got and pay as big dividends as possible. If the fashion changes, you must change your productions to meet the new fashions. Well, all this is very good, very true, and very business-like, but there is something more wanted. Reform seldom comes from the inside, and therefore if outside opinion was withdrawn almost all reforms would be long a-coming. We may be wrong in our opinions, but they have often been expressed and not controverted. It is, however, to insist, and insist, and insist upon views not generally adopted till a majority is obtained in their favour. The chief difficulty in constantly harping upon a particular point is that you are taken to be the exponent of that one system only. We have no wish to push direct-current distribution against alternate-current distribution except that the latter seems to be delaying the adoption of electric energy for the production of power. Much has been heard but little has been seen of economical alternate-current motors. With a little perseverance the use of motors should be rapidly extended, and we have no doubt that if direct currents had remained in fashion they would be largely used. It is but a few days ago since the enterprise of the *Pall Mall Gazette* was highly commended by almost every paper in the land. It was long ago said that newspaper information comes by lightning, and it ought to be largely said that they are printed by the aid of electric energy. We are quite sure, however, if the figures are rightly examined, that in a large majority of cases where small power is required, the use of electric motors would conduce to saving. The old saying that "truth will prevail" may be quite true, but the almighty lie prevails for too many years to allow us to come to a conclusion on that subject. The user of power is filled with information concerning steam and gas engines, and is told that one pound of coal burnt in the furnace of the steam-engine will produce so much power, and that so many cubic feet of gas exploded in the cylinder of a gas-engine will produce so much power, and that he can get a horse-power hour for a very small sum of copper coinage. It is not quite possible to determine how much of this he believes, but the fact remains that whether as a small user of power he uses a gas or a steam engine, his power will cost him more than the theoretic figures put before him to charm his order. No doubt a horse-power hour obtained by means of an electric motor will also cost more than the theoretic amount as given in text-books or in papers read before learned societies, but the additional cost will, we believe, be far and away below that incurred with steam or gas.

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In a very large number of cases where a small steam-engine is used coal is always burning in the furnace, but the power is required but intermittently. In such cases a great advantage is obtained by electricity, in that the current is turned off the motor when the power is not required and turned on when it is required. The power used may, while used, cost more than that from steam or gas, but the bill stops as the machine stops. We do not care to enter into the vexed question of economy under varying loads, for with electricity we get as good economy as with steam or gas, if not better. Allowing, however, that there is no advantage in this, the advantage previously mentioned is enough to warrant our support of motors. Is it possible, then, with the alternate systems now so often used to obtain the development in motors which is so desirable? Nothing need be said of the value of a large power distribution to central stations. That is not the light to view the question. The public must be shown to benefit before it will purchase, no matter the benefit such use and purchase will confer upon the station. Will not some of our towns and some of our consulting engineers think over this matter, and not be guided solely and wholly in their works and designs by the expected demand and extension of demand for light? We think, if experience is needed, the experience of Bradford would be enough to show that "power" distribution must ultimately prove a big factor in central-station work. If the required alternate-current motors are forthcoming, there is little need to trouble about direct or alternate work. Other questions will decide which is preferable.

THE BOARD OF TRADE AND ELECTRIC TRACTION.

It is just a month since we commented in these pages upon the conference then held under the auspices of the Board of Trade for the purpose of discussing and amending the draft rules and regulations prepared by the Board's official staff last autumn as a consequence of the Joint Parliamentary Committee's report on the above subject. No unnecessary delay or waste of time has since been incurred by the Board after once receiving full explanations and comments from those more especially interested; for the complete regulations as finally settled and agreed upon are now published in readiness for insertion in all Acts or Bills relating to such electric lines as may be called street tramways, whilst at the same time draft regulations are issued concerning the electric railroads running underground of a type similar to the City and South London Railway and the numerous other subways proposed to be made in the metropolitan area and elsewhere.

When last commenting upon the subject, we made it clear that great credit was due to the Board of Trade as a Government department for the extremely fair and unbiassed way in which objections to its rules as first drafted were met and accepted. Naturally, therefore, we need say no more on this point, as it was only to be expected that such a line of action would be continued, and that the rules as finally amended would give satisfaction all round, so far as that be possible. Certainly, the electric traction interests have no real ground for objecting to the rules as now made standard, taking also into account the verbal expressions employed by the Board's chief officers as to the feeling of this Department in the matter. This feeling may be characterised as one of friendly interest in electric traction, coupled with a wish to help it forward, rather than hinder its progress by exacting slavish adherence to minute details of the regulations, provided that real efforts are made to comply with their spirit.

Turning to the regulations now set forth in their final shape, it is an easy matter to ascertain the changes effected by united action of the electrical interests by comparing them with the draft rules published last year (see the *Electrical Engineer*, 24th November, 1893); but the operation would prove somewhat tedious, and we can therefore only refer to a few of the most important alterations accepted by the Board. The preliminary definitions remain the same: Rule 1 is modified so as to better explain the term "steady" as applied to the generator, or supply, current. This must now be "without appreciable pulsation." In Rule 2, the words "insulated throughout its length" are struck out as referring to the line wire, thereby avoiding the troublesome question as to whether such insulation is "from earth" or of an absolute type implying a covered wire. Rule 3 allows uninsulated returns to be within three feet of the rails, not necessarily between them; and also permits their use generally when of sufficient sectional area. In Rule 4 a similar latitude of three feet is allowed for uninsulated return conductors to be connected to the rails.

Rule 5 is materially qualified as regards making connections with earth from uninsulated returns: the size of water-pipe to which connection is permissible being reduced from four to three inches, but the consent of owner and water company is essential, together with metallic connection to earth-plates. Rule 6 was very fruitful of discussion at the Board of Trade conference, and has been considerably altered; the chief point is a virtual increase of the ten amperes limit of earth current to two amperes per mile of single line, or 5 per cent. of the total current output. On Rule 7 the Board has adopted in its entirety the suggested amendment of the London Chamber of Commerce Traction Committee, much to the advantage of the traction interests.

The next item to notice is in Rule 10, where the limit of leakage current is raised from one-tenth to one-half ampere per mile, and twenty-four hours are given to localise any fault before stopping traffic. This, of course, does not apply to conduit lines. Rule 12—rather a tiresome one, allowing aggrieved owners of adjacent wires to protect themselves by anti-induction appliances in the tramway wires—is, we are glad to see, qualified by appeal to the Board. The real bone of contention lay in Rule 14, which has had all the sting taken out of it, though a great deal of uncertainty may yet be found lurking within the expression "reasonable precautions." Nothing of great importance requires notice in the other rules,

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and taking them all in all as they stand, the traction interests are to be heartily congratulated on the success of the efforts made by the Institution of Electrical Engineers, the London Chamber of Commerce Traction Committee, and others to secure their adoption as amended.

As a consequence of this preliminary clearance of the ground, we confidently hope and expect to chronicle in the early future some real solid progress in electric traction. The conditions now laid down are not by any means too onerous to prevent success being achieved under proper supervision and maintenance, whilst they are certainly of such a character as must tend to keep down reckless schemes. Although, therefore, an admirable opening is to be found in this direction for the profitable employment of money, good results will only be obtained by the exercise of every possible care such as an excellent management would consider essential. A wide field is now open—almost untouched—with supervision of an indulgent nature to the well-behaved. We shall be greatly surprised if there are not many eager to avail themselves of the opportunity.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

INVENTORS AND PATENTEES.

SIR,—Mr. Fitz-Gerald's letter most opportunely negatived to some extent your leader headed "The Guileful Patentee." I would suggest you amend its title, and call it "The Innocent Financier." I, for one, and I know many other electrical engineers, have a great respect for your paper, and the fair-minded way in which it has represented the electrical industry, but your leader is distinctly retrograde. You have evidently taken a lesson from one of your contemporaries, and I venture to say a bad one.

You write with strong disapproval of the men who 12 or 14 years ago were the pioneers of the present electric light enterprise, the majority of whom have unfortunately failed in reaping any benefit for much labour and money expended in discovering, experimenting, and patenting what at the time were new and necessarily untried inventions; and you seek to protect the guileless capitalists, and the would-be financial agents, and company promoters, whose sole desire is to accumulate wealth speedily at the expense of other people's brains and money.

Your leader will have the effect of discourging inventors—*i.e.*, the men who create new industries by which and from which new business germinates—the men to whom this country is indebted for its prosperity, and the perfection of machinery and apparatus which alone enables our manufacturers to hold their own in competition with other countries.

If a few of such men as Wheatstone, Hughes, Wilde, and, in later times, Edison, Siemens, Swan, and others, have reaped some advantages, that does not in any way compensate the enormous majority of inventors who have lost their all in ambitious efforts and honest endeavours to rise above their surroundings. I could name a score of such men, all well known in the electrical world. Some, like poor Lucien Gaulard, are driven to despair and suicide—he asked for bread, but ye gave him a stone. Gaulard's letters and the story of his struggle is pitiful reading.

Your opinion of the readiness of the level-headed men who manage firms and companies to take up new inventions is entirely fallacious: they do just what seems to them best to serve their own ends, and more often than not suppress any new invention, however meritorious, which might interfere with their own tried patents and trade monopolies; and, as I shall point out, the patent laws enable them to do so, and I am bound to say, in justice to them, are a cause of their so doing.

I have been under the necessity of searching through, I may say, some thousands of patents, and I say advisedly that the majority of patents are earnest, painstaking efforts to secure perfection, and as such should not be grudged any reward they may, if lucky, receive. On the other hand, my own experience of capitalists and financial agents is that they do not require championing or safeguarding; they are well able, and indeed always do protect themselves, and take the lion's share of any profit that may accrue from an invention. This is undeniable.

Now, Sir, I come to the real issue, and the reason why there are dishonest patentees (not inventors). I unhesitatingly say it is due only and solely to the existing patent laws of this country. Say there is a new departure, or a discovery that may be brought into practical use if only inventors or improvers can find their way to do so. There are scores of men, born with inventive and fertile brains, who set themselves to seek a way—a few succeed, or partly succeed—and to secure their ideas take out patents. Now comes the crux. What does the Patent Office give them for their fees—a right? No. A monopoly? No. They pay the fees for a vain protection, not tenable or maintainable against money. The patent laws of this country gives no right or security to the invention of a poor man; a patent is of no value until it has been proved, often at an immense expense, in a court of law. There is no search, no investigation into the novelty or priority of his invention, and, unfortunately, no refusal by the Patent Office authorities; they take the fees, and only give in return the doubtful advantage of publicity. If the invention becomes of note, it is more often than not assailed, with the result that the patentee has either to give up his rights or make sacrificing terms with the greedy capitalist or financier. On the other hand, the absence of all check, search, and investigation by the patent authorities enables the dishonest patentee to secure any patent and to trade upon the empty title it gives, and so to dupe the people of their money; in fact, the absence of all investigation makes it easy for rogues to create a fictitious patent and palm it off as a novelty. In the course of my searches I have actually found patents in great part copied, word for word, and reproduced and repatented years after the date of the original patent by others (I need only mention such patents as fluids for use in batteries, etc.), and it is a fact there is no check, excepting only the nine months' previous record, upon patents. That is the real cause of the dishonesty and the origin of the "guileful patentee." I say that the present patent laws which will grant any man a patent provided the fees are paid is a monstrous injustice, and a curse and a cause of crime. It is dishonest, inasmuch as it gives no tangible right to the honest inventor in return for his fees; it is dishonest, as it indirectly incites and holds out the strongest temptation to dishonesty in patent-mongering, and it thus gives a premium to dishonest patentees.

If the patent authorities were empowered by statute to make a thorough search and examination into the priority and novelty of inventions before they grant a patent, as is done in the U.S. of America and Germany, then, I venture to say, there would be an end of the dishonest patentee and his bogus patents, and the patent granted to an inventor would be a fair return for his brains and money and the fees charged by the Patent Office. Such a patent would be a real protection to him, and an inducement to the level-headed managers of firms and companies to entertain without the expensive search and investigation now absolutely necessary; thus the real inventor would stand a fair chance of reward, whilst the rogue would be shut out.

Inventors, as a class, in my opinion, deserve your warmest support, and I ask, what I am sure you will give them, a fair discrimination in your criticism. It is hard enough for honest and genuine inventors to make even fair terms with capitalists, etc., and they are entitled to look to their own trade journals for at least fair play.—Yours, etc.,

HENRY F. JOEL.

London, March 21, 1894.

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IMPORTANCE OF COMPLETE METALLIC CIRCUIT FOR ELECTRIC RAILWAYS.*

BY J. H. VAIL.

In the early days of electric railway construction two distinctly different systems were devised and competed for public favour, the one being the overhead double-trolley system, affording a complete metallic circuit for the outgoing and return of all the electric current required to move the motor cars, and the other being the single-trolley system, using the track and earth as a common conductor for one side of the circuit, and the trolley wire and parallel mains for the opposite side. The double-trolley system was found impracticable of operation in many of its details, and the single trolley, because of its simplicity and convenience, has made rapid advances in public favour. The single-trolley system has depended largely upon the earth and buried pipe systems for completing the circuit.

Many devices for making the track and earth combined a more complete and low-resistance circuit have been resorted to—such as burying copper or iron plates, old rails or old car wheels, and connecting the same to the track; or, at frequent intervals, driving iron rods down in the earth and connecting by wires to the track; or by making actual connection with wire from tracks to gas and water pipe systems. Also, for supposed reinforcement of the track, we have used a bare wire of iron or copper, buried in the earth, laid parallel to the track, and connected at frequent intervals; also the supposed electrical connection of rails at joints by bond wires of iron or copper, only having a small fractional part of the capacity of the rail as a conductor. In the early days of electric railway construction it was assumed by experts that the earth and the buried pipe systems would, when combined, form an ample return for the electric current. At that age of the art experts did not fully appreciate the immense quantities of current that would be carried, and therefore did not foresee that these currents when disseminated would produce the serious results that have been caused by electrolytic action on systems of pipes buried in the earth and owned by other companies. Frequent tests prove that the earth itself cannot afford the free path for the current that was anticipated. Earth conductivity has been over-estimated. Iron and lead pipes, being better conductors than earth, must of necessity carry the current, if no superior path is offered by the method of construction. The natural moisture of the earth hastens the destructive electrolytic action of the current on these pipes. In some soils electrolysis is more rapid than in others. The rapidity of action depends upon the chemical constituents of the soil.

It has been found that illuminating gas leakage held in such soils as underlie the cities of New York, Brooklyn, Boston, Philadelphia, and elsewhere, hastens electrolytic action. To prove that the methods of work mentioned are still in vogue, I quote the following section from specifications recently sent out from the office of a prominent electric railway company:

"*Bonds and Supplementary Wire.*—Each rail shall be connected together by two bonds, made of No. 4 galvanised iron wire (Roebling gauge), to each end of which shall be brazed two $\frac{9}{16}$in. Norway iron rivets. Both of the bonds shall be separately connected with a No. 0 galvanised iron supplementary wire, by means of No. 4 galvanised iron wire connections, which shall receive at least four turns around both the bonds and supplementary wire and be thoroughly soldered to the same. Ground-plates shall be placed about 1,000ft. apart. They shall be buried not less than 8ft. in the ground, preferably in damp places, and two No. 0 galvanised iron wires shall be brazed to the ground-plate, and connected one to each supplementary wire in each track, by thorough wrapping and soldering. The ground-plates shall be of galvanised sheet iron, 2ft. square and $\frac{1}{8}$in. thick, bent around in the form of a spiral."

It is evident that electricians had then perfect faith in the earth as a conducting medium. Evidence had not been produced that Mother Earth was incapable of carrying the enormous quantities of current required; neither had an opportunity been afforded to demonstrate her capacity. That some still have faith in the earth's ability in this direction is attested by above specifications and other constructions being executed at this date.

Having briefly reviewed the practice for the past few years, let us now have a look at the resultant effects. In cities provided with electric railways destructive electrolytic corrosion is now acting upon gas and water pipes, and will inevitably produce serious impairment of all such underground pipe systems within a brief period, unless prompt measures are taken to prevent further damage. Within the past year strong evidence of damaging electrolytic action has been produced. Simply for the sake of fixing the evidence on your memory, I will mention only seven instances of electrolytic action of railway currents on gas and water pipes in different cities.

1. A section of iron water-pipe shows complete perforation, caused in four weeks' time. The lead covering of telephone cables also show serious damage. A large number of additional items will be found in the report to Board of Electric Subways for 1893.

2. A plumber in a city in Pennsylvania was repairing a water-pipe in a house, and on breaking joint, an electric arc formed across the separating ends of the pipe. This house was not in the direct path of the railway circuit. Investigation followed, proving beyond question the insufficient electric conductivity of the track system; also that the earth did not afford a good return though the tracks were well grounded. It was found that the railway current was travelling all pipe systems in its effort to complete the circuit to the dynamos in the power station. Actual tests were here made by an expert, using standard instruments. From 135 readings of the ampere-meter it was found that the feed-water pipes leading in the station carried an average current of 93 amperes. Further careful test proved that with 23 cars in operation on the system, 40 per cent. of the total current was carried on the underground pipe systems.

3. December 15, 1893, a fire occurred in the basement of James Sutherland's house. After being extinguished, investigations showed that the current of the electric railway system had been carried along the iron water-pipe, and that probably by vibration causing the pipe to come in contact an arc formed between the water-pipe and gas-pipe, burning a hole through the gas-pipe and thus set fire to the gas. The house was saved by prompt action.

4. Tests show the electric railway current present on the water-pipes. In the generating station the fireman gets a shock when he opens the furnace doors of his boiler with the bare hand.

5. A test recently made by an expert engineer developed the fact of a loss of 24 per cent. on the system, and a difference of 25 volts potential between parallel tracks opposite the power station.

6. Prof. Barrett, in an exhaustive report to the Mayor of Chicago, states that "this destructive action is not alone confined to the lead covering of telephone cables, but is acting on gas and water pipes and almost all buried metalwork," and that it can only be a question of time when more disastrous results will manifest themselves.

As further and substantial evidence, I here exhibit for actual examination a section of 6in. water-main from city No. 7. This pipe has been entirely corroded through by the action of the electric current of the street railway system, which was constructed under my direction about four years ago. This effect was produced in about 2½ years; another section was rendered useless in six months. Abundance of additional and substantial evidence can be produced. These serve to prove the case, which can no longer be successfully denied nor assigned to other causes.

It has been stated that in an electric railway system where a connection has been made to water-pipes, the pipes have carried as much as 28 per cent. of the total current. Instances are known where as much as 40 per cent. is carried on the pipe systems. It is the opinion of the writer that any gas or water pipe system used as a carrier of electric currents will not only be corroded through the body of the pipes, but will surely in due time show defects at joints, as here will occur higher resistance than in any other portions of

* Paper read before the National Electric Light Association, Washington, February 27, 1894.

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the pipe system. It has been proven by test that the electrolytic action of even five amperes of current on an iron pipe is considerable, and that much damage will result in one year. The rapidity of action depends upon character of soil, amount of moisture, and quantity of current; the destructive action is constant and sure.

I do not wish to create unnecessary alarm, but there can be no question that a grave danger confronts us, and must be surmounted. Instances are numerous proving that the electric railway current is present on the gas and water pipes in buildings contiguous to electric railway lines. Even those of us who are familiar with handling the electric current hesitate to draw a combination of electricity with our gas or water. We know that the gas and water pipes entering our houses may be charged with such a current, and that it only remains for the circuit to be completed by a possible accident through our bodies, or the occurrence of a fire by automatic action between vibrating pipes. City engineers, water companies, and gas companies are placing the responsibility upon the railway companies for the damage caused on pipes by electrolysis.

Any system using ground-plates ground-rods, or substitutes therefor, or bare return track wire buried in the earth, is constructed primarily to utilise the earth as return circuit; when the earth does not afford good return, the current is sure to follow the water-pipes, gas-pipes, or other buried conductors offering the path of least resistance. We now see that these prove to have been only make shift methods to reduce the cost of construction. We find that the evidence thus produced and the troubles constantly occurring in existing street-railway systems are sufficient to show that all methods of grounding the track circuit or connecting to pipe systems should be entirely discontinued; it therefore becomes of vital importance to so construct the electrical railway system as to avoid all electrolytic action on buried systems of metal work that are the property of other concerns.

Having produced the evidence and established the case, let us briefly analyse the matter and ascertain the reason for these results. The whole case may be stated in the single sentence, that the electric current must under natural laws follow the path of least resistance. What was intended to be good has proved to be defective electrical work executed in connection with track systems, has not given to that side of the system a perfect path for the travel of the current, the conductivity of the rail circuit being impaired to such an extent that the electric current must force itself through the earth or through metal pipe lines buried therein.

We must here diverge for a moment to show how the incandescent electric light system operated in multiple arc compares with the railway system. An electric railway system may in some degree be compared with a system of electrical distribution for incandescent lighting, the groups of lamps in buildings connected in multiple arc, comparing with each car and its motors demanding current. The systems otherwise differ in important particulars; the load on the electric light system is not subject to such violent fluctuations as on the electric railway, where the instantaneous demands for current and its equally prompt release must be controlled. The current required for the car is a moving load as the car progresses on its route; this and all other differences of conditions must be duly considered when laying out the system of distribution. With the electric lighting system, the current for consumption is derived from the mains, the equalisation of pressure is maintained through the feeders: the mains are of equal capacity on either side of the system.

With the electric railway the track forms one side of the consumption circuit, and must be so treated in regard to distribution of current as to utilise its carrying capacity equally with the other side, and thus equalise the delivery of current. The electric conductors composing a system of distribution for electric railways should be so thoroughly well proportioned as to show the minimum variation of pressure throughout the system, even when the entire number of cars are in operation. This equality of pressure is an important requisite for the economical working of the motors. The writer has tested electric railway systems operating with a station pressure of from 500 to 550 volts, and showing only 300 to 325 volts on various divisions of the system. Here is a direct loss between dynamos and motor car of over 40 per cent. Is it, therefore, any wonder that some roads report extraordinary coal consumption? Such loss in pressure indicates radical faults in the original planning of the system and the distribution of copper. When operating under low voltage, the motors demand an increased quantity of current above what should be the normal supply, thus augmenting the heating effect in the armatures and fields, the efficiency of the motors being reduced in corresponding ratio.

A further examination into other features of construction requires some consideration of the bonding of rail joints. The existing methods of utilising railway tracks for conducting large quantities of current are faulty in at least three particulars: (1) Restricted conductivity at joint, due to insufficiency of the rail bonds. (2) Neglecting to properly utilise the track as a conducting medium. (3) Failure to provide a complete circuit of low resistance.

For electrical purposes we cannot regard the joint plates and bolts as of any permanent value; the contact is electrically imperfect, the metal surfaces oxidised and under constant movement, due to passing cars pounding the rail joints. The rail sections are in many systems of ample conductivity to carry more than the requisite current provided they are perfectly bonded and properly connected by feeders with the dynamos. We must, therefore, bond the rail joint in such a mechanical manner as to maintain perfect electrical contact, and with sufficient metal to restore at the joint nearly the full conductivity as of the rail itself; and at the same time to give the existing joint plates their present freedom of motion.

It has been found that a system of track with faulty rail bonds will give a shock to animals and, possibly, to human beings, should the same be brought into actual contact in such a manner as to complete through them the broken circuit. It will be readily understood how difficult it is to maintain proper inspection of the electric bonding where the bonds are covered up by the street pavement. Under such conditions the ground circuit and the bonding escape inspection until excessive coal consumption, loss of current, and other troubles force themselves upon the attention of the street railway management.

Observation proves that a faulty rail bond will show its location in winter by heating, due to high resistance, and if snow be present on the ground around the joints the snow is partially melted, thus indicating location of fault.

Let us turn our attention for a few moments to the question of the conductivity of the rails.

For the purpose of comparison, we will assume that iron has six times the resistance of copper. (The actual proportion being 1 to 5·63.)

CARRYING CAPACITY OF RAILS (prepared by G. F. Sandt, E.E.)

—	56lb. rail.		70lb. rail.	
	One rail.	Single track of two rails.	One rail.	Single track of two rails.
Area in square inches	5·4874	10·9748	6·8593	13·7186
Equal in area to circle whose diameter is in inches	2·642	3·735	2·95	5·90
Equivalent in cir. mils to	6,980,000	13,960,000	8,702,500	17,405,000
Resistance per foot B.A. units	·00000845	·00000422	·00000679	·00000339
Equivalent to copper resistance in cir. mils	1,175,000	2,350,000	1,463,000	2,926,000
Equivalent to copper rod whose diameter is	1·13	1·533	1·21	1·71
Safe carrying capacity of iron reckoned at one-third that of copper in amperes	390	780	488	976

Note.—In the above statement the areas of rails have been determined by use of the planimeter. The ampere capacity of iron has been based upon the most reliable data obtainable. The author believes that the figures submitted are sufficient for comparisons, but cannot guarantee their absolute accuracy.

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The following table gives the current strength that can be carried by iron wire, within doors, in still air, and without becoming unbearably warm to the hand—that is, not to exceed a temperature of 50deg. C.:

B. & S. gauge.	Amperes.
10	16
9	19
8	21
7	25
6	28
5	32
4	37
3	43
2	50
1	58
0	67
00	77
000	90
0000	105
½in.	117
¾in.	203
1in.	302

Data furnished by A. E. Kennelly, February 12, 1894.

These figures serve to show how utterly absurd it is to bond a track of 70lb. T rails with iron rail bonds No. 4 or No. 0 in size, and to pretend to reinforce their conductivity with a No. 0 iron or even a No. 0 copper wire. It is like laying a 12in. water-main and then putting a ½in. pipe alongside to help it out. The No. 0 B.W.G. copper wire has a resistance of over 20 times the single track of 56lb. T rails per foot and the No. 0 B.W.G. iron wire over 112 times the resistance per foot of the same track. How, then, can either of these be of any adequate assistance for conducting current?

The following lines indicate the small value of a supplementary wire of either iron or copper when compared with the conductive capacity of a properly bonded single track of 56lb. rails. They represent areas in accurate proportion for comparison. Fig. 1 shows the diameter of a circle indicating the single track of 56lb. rails. Fig. 2 represents the iron reduced to resistance of copper. Fig. 3 shows the No. 1-0 supplementary copper wire and Fig. 4 the No. 1-0 supplementary iron wire reduced to resistance of copper.

Fig. 1.

Fig. 2.

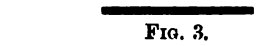

Fig. 3.

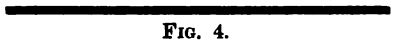

Fig. 4.

The writer knows personally of several instances where the copper supplementary wire has absolutely disappeared. The writer believes that 99 per cent. of the money expended for so-called supplementary wire is absolutely thrown away. The same money expended in other directions will give more adequate return.

Does not this show conclusively that we should give our attention to the more perfect bonding of the rail joints, and also to apply track feeders in such a manner as to fully utilise the conductivity of the track and thereby make it fulfil the service of which it is capable when properly treated? We are in error when the track system is named as a return circuit. The track system of all electric railways should really be the positive side or outgoing circuit. The writer fully explained this in a brief article in the *Street Railway Journal* about a year ago. It will be readily understood that as the current travels from positive to negative, therefore any arc which occurs between the trolley wheel and the trolley wire will carry metal from the trolley wheel and deposit the same on the trolley wire. If the reverse method of connection is made, the trolley wire will lose the metal, the same being deposited on the trolley wheel, and in time the strength and conductivity of the wire must be seriously impaired, eventually resulting in breakages.

It is also important that existing systems of operating electric railways should be promptly taken in hand and the proper remedies intelligently applied. The three-wire system has been mentioned by some engineers as a possible solution.

I will here diverge for a minute to state that a trial was made four years ago under favourable conditions—not to avoid electrolysis, but to save copper. We developed physical difficulties of operation which warned us to avoid the three-wire system in future electric railway work.

I believe I am safe in stating that 90 per cent. of the electric railways have their systems so constructed as to largely restrict the conductivity of the rail circuit.

A one sided system is fundamentally wrong. The quantity of current to be controlled is so enormous that ordinary makeshift methods will not answer.

Having carefully analysed the whole matter, I feel justified in recommending that we must adopt the complete metallic circuit as the standard for the best electric railway practice. This can best be obtained by the following method:

1. By so bonding the track as to render the rail joints of as low resistance and nearly equal conductivity to the rails, and to execute this work so as to maintain this improved condition; and

2. The track system must be supplied with insulated feeders leading direct from the 'bus bars in the station to predetermined points of the track system, and thus offer a perfect low-resistance path for this side of the electric circuit, the same as obtained with the trolley line and the overhead system. All of these features and improved methods have been put in practice by the writer.

The only proper system is one that affords a well-insulated and complete metallic circuit of low resistance, that will give an ample path for the complete unrestricted circulation of the entire current from pole to pole of the dynamo, thus offering no inducement for the current to follow such conductors as gas or water pipes, but, as it were, actually robbing the earth of any desire to carry the current. I am not recommending extravagant methods, but only such as are deemed essential for economy, and of a practical nature for reducing expenses and augmenting dividends. The item of cost cannot properly be urged as an objection, because where the whole construction requires a large investment, every detail of the work should be so executed as to be permanent and enduring. If the details are carefully analysed it will be found that the cost of frequent reconstruction, maintenance, and renewals of rail bonds and bare wire amount to an excessive rate of interest on original investment, and would soon pay the small additional cost to build a complete metallic circuit. The superior service obtained from a complete metallic system of low resistance with the proper application of insulated track feeders will, within a brief period, more than refund a reasonable interest on the investment through the saving of fuel alone, not counting other economies in renewals and maintenance. The track-feeder system will be far less costly than the double-trolley system.

Whether track feeders should be laid underground or erected overhead is a question largely controlled by local conditions and capital available. I express a preference for underground work as being more permanent and subject to the least cost for repairs. The original construction is certainly more costly for underground. The actual cost of copper is the same in either. The necessity of constant repairs under existing methods, and the damage to water and gas pipes by electrolytic action, simply proves that it is but a question of time as to how long before electric railway companies will be forced to adopt the complete metallic circuit. Where experience and practical knowledge is applied, the cost will not be excessive. It is not difficult to arrive at an exact method of doing the work and an accurate estimate of its cost.

The writer has observed on some roads that large quantities of copper for return circuits have been placed at great expense, apparently without a proper conception of how to obtain the best results. Frequently a far less amount of copper, judiciously applied for improved distribution by the feeder system, would give superior equalisation of pressure at reduced cost.

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If for the movement of cars singly or in quantities at a high rate of speed the electric current is to be distributed uniformly over an electric railway system, the subject must be handled with as much scientific accuracy as is always used for a perfect system of incandescent lighting, in order to obtain equal distribution and free flow of current in both sides of the system.

The writer has fully and completely provided for all contingencies in the following manner:

1. By a careful study of the conditions under which a system will be operated; these important points being ascertained with reasonable accuracy, the requisite supply and distribution of current for the service is determined, and the system of conductors arranged to meet the requirements. For the proper supply of electric current, the important underlying principles of the feeder system must be thoroughly understood.

2. The conductivity and current-carrying capacity of the track system is calculated, and a system of insulated track feeders is provided, leading from the switchboard in station and connecting at predetermined points, and with a calculated fall of potential.

Each feeder must be determined for its maximum current requirements at a stated drop in potential. The actual work required of the feeder and number of track feeders necessary is determined upon such factors as:

The cars in service—their weight, speed, and headway; the position of power station and the geographical lay of the railway system; the weight of rails, and whether double or single track, and the amount of load concentrated on sections of track between feeder junctions.

The carrying capacity or conductivity of the sum total of all the feeders of the system will be found to give complete and ample circuit for the free flow of the entire current required, and to take care of extra heavy traffic and blockades at any point.

The parallel track main is only applied in sections of systems extending over very large territories and long distances.

The conductivity of the rails is calculated with as much care as the overhead system, and when the track needs reinforcing, the purpose is accomplished by laying a thoroughly insulated main line (not a bare line) and making frequent sub-feeder connections bonded to the track. If used at all, this main will be of large size.

Such a system, accurately worked out, will show by actual test with instruments on the cars a surprising equality of E.M.F. throughout a large territory.

A very careful test has been made with instruments on moving cars, throughout a system covering 40 miles of streets, with double tracks, equal to 80 miles single track. The readings showed: maximum volts, 512; minimum volts, 420; average of E.M.F. over entire system, 460 volts; the E.M.F. in station, at 'bus bars, being 520 volts. The feeders were calculated for 10 per cent. drop. The actual average drop from dynamo to motor does not exceed 12 per cent.

This will be found to result in reduced fuel consumption, better working of the motors, a most satisfactory reduction in repair accounts, and an improved general economy of the entire system.

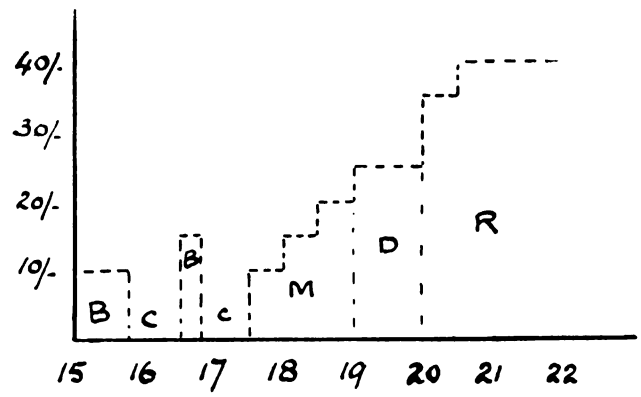
In the system of distribution secured by the above method, the use of ground plates, rods, or other insufficient methods is needless; the current travels only over the paths provided for it, and electrolysis of gas and water mains is entirely obviated.

A CAREER DIAGRAM.

We all remember the characteristic little incident in the life of one of our best engineers early in this century, when the "timmer" hat which he had turned in his "bit lathie," secured for the ingenious young Scotchman a position in which his capabilities found full scope for development, and made his after-life one of honoured labour.

There must have been something of the same originality of idea in a young electrical engineer who came to us a little while ago to see whether we knew of any opening through which he might carve his way to success in life along one particular direction: and one would feel inclined to say of him that the odds would be in his favour throughout.

On asking what he had done, the nature of his training and experience, etc., he brought out—not a written biography: "I left college at eighteen, spent two years with So-and-So, then went to Brown, Jones, and Co.'s works, etc."—but a diagram somewhat after the following style,



wherein was shown at once his career from the time of leaving school to date, as well as the rates of wages at which he had been paid. This "career curve" represents a young fellow's progress in an admirably clear and condensed form, and it would be to the advantage of all employers to insist on those who propose to enter their service presenting such a record in brief of their life and labour. Probably there might be thousands whose diagrams would not show up well, which is all the more reason for seeing them and comparing any in competition for a given post.

The young engineer in question explained his diagram as follows. He had as a boy spent much spare time in drawing, and at the age of 15 he found no difficulty in getting employment in an electrical works—B—as tracer, at 10s. a week. He stayed here for nine months, then spent the next nine months in theoretical and practical work in one of the electrical colleges to such good purpose that during the summer months he was taken on again by the same works at 15s. a week. Then the next session was given up to more practical work at the college testing-rooms, etc., with spare time devoted to picking up hints in a friend's machine-shop and foundry.

At the end of the college session he found no difficulty in getting employment on telephone and telegraph work for one of the railway companies—M—though to begin with his wages were only 10s. Regular advancement, however, doubled this in a year's time; and then an opening was offered with a firm of electric light contractors—D—at higher pay. After a year with them he again had a chance of improving his position with another firm—R—who were paying him 40s. weekly at the time of his call.

It need hardly be said that the ambitions of this young engineer bid fair to be very largely realised. It is just such men that are wanted to-day and always—men able to think and reason sensibly for themselves—and the more there are in the electrical industry the better for it.

NORTHERN SOCIETY OF ELECTRICAL ENGINEERS.

We give below a report of the discussion which took place on the papers read last week before this institution by Mr. John H. Rider, entitled "Notes on Designing a System of Underground Electric Light Mains," and by Mr. S. V. Clirehugh, A.M.I.C.E., on "Various Systems of Underground Mains and Methods of Laying Same." The papers were published in our last issue, and by the courtesy of Mr. J. Darney, the honorary secretary of the institution, we are now enabled to give the discussion on them:

Mr. Wordingham said: As regards the general questions of mains, from my point of view the most important thing is

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durability rather than high insulation. Take the case of vulcanised rubber cable. In Whitehaven we had a resistance of 1,870 megohms—not per mile, but the whole system as laid. Suppose you put on 1,000 consumers, each of one megohm, then the insulation resistance would only be 1,000 ohms. It is no use putting thousands of megohms if the general resistance is only a few thousands. Under these circumstances I think the thing to be looked for is durability. There can be very little doubt that copper is durable; it sometimes corrodes, but I have not noticed it here except in one or two places where water has got into the boxes, and then only very slightly. As you know, we have in Manchester partly bare copper in culverts and partly rubber. The resistance of bare copper is low. As to actual figures, I should not care to give any without having considered the matter first, but the figures which have got about are rumours which are simply absurd—the resistance would only be a few ohms; instead of that it is certainly hundreds of ohms. As to rubber cables, I believe if the joints are properly vulcanised you can get perfect insulation. Of course, where rubber is joined on to bare copper, you must see that the braiding is properly pared back. With regard to the question of vulcanising joints the difficulty has been, I think, a little exaggerated; no doubt there is a large amount of difficulty in ascertaining the right duration of time for different mixtures and temperatures, but once the manufacturers gain this experience for you, and supply you with vulcanising material that is ascertained to be good, there is very little difficulty in vulcanising joints. I do not think the difficulty of vulcanising is great, and I think it is most unwise to omit it—it simply means an extra 20 minutes. The great convenience of bare copper is the ease of getting on consumers—you simply have to sweat on a pair of thimbles and clamp them on to the bare mains.

Mr. A. B. Mountain, of Huddersfield, observed: I think the two papers we have heard read are very interesting, and will require careful discussion. I cannot agree with some of the remarks referring to vulcanised indiarubber cables. There are, no doubt, certain difficulties in jointing these cables, but these difficulties are overcome by ordinary care. I think the system of drawing vulcanised cables through cast-iron pipes is in every way satisfactory for feeders or high-tension mains. The cables insulated with bitumen, paper, or fibre may be very good for low-tension mains, but are, I think, unsuitable for high-tension work unless laid with great care and at very considerable expense. You have just heard Mr. Wordingham speak of the insulation resistance of the Manchester mains. There, of course, you have the continuous-current system with probably all the consumers connected on to one network. In the case of a town supplied by an alternating current the network would be divided—I presume that is Mr. Rider's idea—and the risks arising from leaks very considerably reduced, because the number of consumers connected on any one section will be a small proportion of the total. It is a strong point with an alternating-current supply, the system being split up into small sections. In laying lead-covered cable underground, such as that proposed for Bolton, there are many points to be noticed. If the cables are laid in ground where there are traces of ashes, you get serious trouble. This has led in many gas undertakings to the adoption of galvanised wrought-iron pipes. Then the cables may be easily damaged by a blow from pick or spade. If the cable is stranded into three, twisted in a spiral form, in the centre of the three circles of insulating material there will be a space not properly filled in, along which I should anticipate moisture creeping, and also when connecting consumers to the three-wire mains some difficulty may be anticipated in ascertaining to which pair of cables the consumer shall be connected, and I should like to know how the cables are distinguished.

Mr. Bourne, of London, stated: There is one thing Mr. Rider mentioned in this, what I might call treble cable. Mr. Rider mentioned that the wires were twisted together, but separate action will depend upon the distance of the centres taking the circumference—*i.e*, it will depend upon the area enclosed. Mr. Clirehugh in many ways under-estimated the capacity of paper as an insulator. I am connected myself with a rubber cable manufacturing company, and I do not advocate the use of paper for putting on cables—it is not my trade. At one time I had the problem set before me to make a cable for an alternating high-pressure current that involved the use of paper, as we see in these cables. Mr. Clirehugh says the insulation on the samples shown is very thin—it seems to be about $\frac{1}{16}$in. The cables I made were successful, and the paper insulation had a thickness of about 17½ mils. There were seven thicknesses of the very finest paper. The cables worked at a pressure of 2,000 volts. You may get enormously high dielectric strength in paper—whether you can get them to combine the requisite strength with durability is a matter about which I have not had sufficient experience to say.

Mr. Corlett, in reply to the Chairman, said he thought it would be much more interesting for a cableman to speak who knew more of the system than he did.

Mr. Jas. Taylor remarked: I do not think I have any remarks—the only thing that struck me was that the difficulty of making rubber joints was over-estimated. This is really a simple matter, but it needs care. As regards paper and fibrous insulation, rubber has had 10 years' experience and paper has not, and in another seven or eight years we may know more about it.

Mr. Connolly said: Allow me to say a word as a cable-maker and as one who has had a fair amount of experience both in the manufacture and testing of cables. We have had two very interesting papers and some very interesting remarks from people who have to lay mains and make use of them, and I think they should look a little to the manufacturers for information on these particular points that they seem to be dubious about—viz., the durability of insulating materials and the trouble in jointing. As far as indiarubber is concerned, indiarubber has been used as an insulating material for nearly 30 years now, and in the earlier days of its use there were troubles and failures, but I know there are cables in use now covered with indiarubber that were made over 20 years ago still working successfully. It has often struck me that the experience in electric light work is more and more falling in line with the old telegraph work—that is to say, we are going back from the lower class of insulation to the higher class, and at the same time we are also going in a great deal more for the drawing-in system which is copied from the Post Office system for the telegraph wires. The only thing we do not follow the practice of the telegraph world in is in the use of guttapercha. The reason for this is obvious. The heat from the electric wires would melt the guttapercha and the cables would fall out of centre, and you would lose your insulation. I cannot conceive any permanent system of underground mains that does not consist of cables that are not insulated but are also insulated with waterproof material, because sooner or later there is bound to be trouble with the insulation unless you can rely upon the insulating material being impervious to water. With lead-covered cables, with cable depending upon the lead for protection, you have the constant danger of a break in the lead or trouble at the extremities—at the ends—and so long as you are dependent upon anything outside the insulating material for your protection you can never feel safe. I can hear on all hands our troubles with these underground copper mains, not so much in Manchester—things are new in Manchester—but in London, Paris, and elsewhere, even in places where there are supposed to be no troubles at all, and it has constantly been forced upon my mind that we cannot rely in a permanent way on anything which does not consist of conductors insulated throughout; and I do not know that indiarubber is the only material that can be used for the purpose, but it seems to be the only one that has been used so far that answers its purpose in any way. I should very much like myself to know of any cheaper material that has the same qualities—that is, as regards being waterproof, not liable to melt with a temperature of, say, 160deg. F., and at the same time as durable as we know indiarubber to be.

Mr. Whiteley observed: Mr. Taylor has spoken on the subject I had in my mind to speak about—the subject of making indiarubber joints. I think that is the only point on which my experience would be of any use. An intelligent workman could get into the way of making indiarubber joints after one or two trials, and very good ones, too. I do not think there is anything else I need speak about.

Mr. Clirehugh: I may say I withdraw my remarks about making indiarubber joints.

Mr. Cowan stated: With regard to Mr. Clirehugh's figures comparing the cost of laying armoured conductors direct in the ground with the same laid in cast-iron pipes, I estimate that for a $^{19}/_{14}$ concentric cable the cost of laying it in cast-iron pipes would be 10 per cent. more than burying the same cable, armoured, direct in the ground, including all costs. Mr. Clirehugh's figures for the cost of laying cast-iron pipes do not agree with mine. He gives the cost of laying 3in. pipes under flagging as 5s. per yard. I believe the gas companies would only allow 1s. 2d. per yard run, and my own experience gives a lower figure than this. I might say a word on the Brooks oil insulation system. I have tried it on a short line and found that it worked on the whole very satisfactory. The pressure was 2,000 volts. We had a dead short-circuit one night after a thaw, but it recovered its insulation the next day. The system did not seem so difficult to lay as Mr. Clirehugh makes out in his paper. I did not lay it, but merely watched the work being done.

Mr. Bourne observed that Mr. Clirehugh seemed to think 10 times a very severe test to subject a cable to. I think if he will take any reasonably good cable, say for 100 volts, it will stand from 10,000 to 25,000 volts—that is my experience. For instance, there was a cable I took out of the Crystal Palace—I do not know whose make it was—there was nothing extraordinary about it, but it took about 62,000 volts to break down that bit of rubber. It was only a short piece, and was being used for a 100-volt circuit.

Mr. Clirehugh: I said for that class of cable—that has nothing to do with rubber cable.

Mr. Andrew: I should like to mention as to the life of a cable. Although vulcanised rubber has only been used as an insulator for 10 or 12 years.

The **Chairman**: For 30 years.

Mr. Andrew: Vulcanised?

The **Chairman**: Yes, vulcanised rubber has been used for 30 years.

Mr. Andrew: Not to any extent.

A Member: Yes, thousands of miles.

Mr. Andrew: My point is this. Although it has not been used largely as an insulator of cables it has been used in other directions. For 40 or 50 years rubber has been vulcanised and specimens are still to be seen, so proving, as well as one can beforehand, that the well-made cables of to day will last at least that time in the future.

Mr. R. Taylor remarked: I should just like to state my experience as regarding vulcanised rubber. I have been engaged for the last 20 to 25 years in indiarubber cable-making at W. T. Henley's and other places. Iron tube cables were made and used for some years previous to that. Hooper's were the first makers, and made some very successful cables. Some were failures, and I do not know the cause; but since then some which were sup-

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posed to be failures have been put under test, and found to be very good at the present time. A little has been said as to jointing. I do not think they should be treated lightly. I have made vulcanised joints 20 to 25 years ago, and the cables are working now in the German Ocean. My experience is that in vulcanised joints, with care, there is no fear of the joint going bad; the greatest care should be exercised, and the workman should be thoroughly trained. I do not think you should send out a jointer as competent after just showing him how the joint should be made. I think you should insist on the engineers sending their jointers to the manufacturer to be instructed, and not send him a few words on paper as instructions, as if you do it is quite certain that eventually some of the joints will break down; and I think engineers should insist on having their jointers thoroughly instructed in the matter of making a joint, and there will be no fear of their joints going wrong.

Mr. Wordingham said: I entirely agree with the last speaker. I should never think of sending out a jointer who was not thoroughly trained. In this city we have had men from the manufacturer of the cable to teach our men; perhaps a couple of months was devoted to teaching our staff. We have had them properly trained, and they have helped to vulcanise before being trusted to make joints themselves. The joints require very great care.

TRADE NOTES AND NOVELTIES.

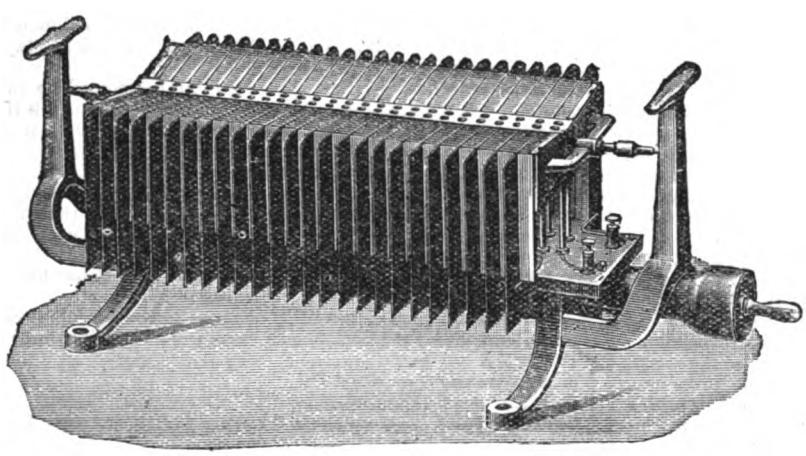
THE GULCHER THERMOPILE.

In many cases the use of powerful batteries, or even small dynamos for toy electrical purposes, may be considered to resemble very strongly the breaking of a butterfly upon a heavy wheel, and yet the waste of energy in generating apparatus of small output is extremely heavy whatever their type. Thermopiles of more or less inefficiency have been devised from time to time with the object of providing a constant source of supply without any trouble, and that devised by Gülcher is not by any means new to our readers, having been introduced to public notice on the Continent some time ago.

It is, however, only of late that this type of apparatus generating electricity by direct application of heat has been placed on the English market by the agents, Messrs. O. Berend and Co., of Fore-street, E.C., and we illustrate here with the most recent form of the appliance.

It consists—in the largest size—of about 32 thermo-electric couples, arranged in two rows with two intervening rows of small gas jets, represented in the illustration by the small holes down the middle of the top surface. In each of these holes is fitted a small cylindrical kaolin or porcelain burner; these get hot in about 10 minutes after lighting the gas, and then are found to give a small current at constant E.M.F. Of course, a flexible tube connection is used for the gas supply, which may be drawn from any source provided it pass through a regulator to maintain the pressure at the proper amount for which the burners are designed.

The makers claim that with 66 elements—having an internal resistance of ·65 ohm—a current of three amperes at four volts



is obtained when the external resistance is equal to the internal, at a consumption of gas not exceeding ·064 cubic foot per hour. This gives an extraordinarily low cost of electric enery, for assuming an output of six watts in the external circuit—*i.e.*, useful work done—the consumption of gas is only about 10½ cubic fect per Board of Trade unit. There are doubtless many purposes for which these appliances might prove serviceable, even at more normal prices for the energy obtained (to pay much less than 2d. or 3d. per unit savours almost of the "sovereign for a shilling" arrangement): for lectures, for working small induction apparatus, in laboratories, and other directions where quite small powers only are needed, there may be a considerable demand for these thermo-electric generators, if for no other reason than because they entirely obviate the trouble of refilling and cleaning batteries, etc.

THE BOARD OF TRADE AND ELECTRIC TRAMWAYS AND RAILWAYS.

THE OFFICIAL REGULATIONS FOR TRAMWAYS.

It will be remembered that in various Acts of Parliament and provisional orders granted last session authorising the use of electric traction on tramways, the duty was imposed upon the Board of Trade of prescribing regulations to be observed by tramway companies for the prevention of injury to gas and water pipes, and for minimising interference with other electric circuits. The Board of Trade having heard the various parties interested, has decided to prescribe regulations in the form given below:

REGULATIONS made by the Board of Trade under the provisions of the —— Tramways Act, for regulating the employment of insulated returns, or of uninsulated metallic returns of low resistance; for preventing fusion or injurious electrolytic action of or on gas or water pipes or other metallic pipes, structures, or substances; and for minimising as far as is reasonably practicable injurious interference with the electric wires, lines, and apparatus of parties other than the company, and the currents therein, whether such lines do or do not use the earth as a return,

Definitions.

In the following regulations, the expression "energy" means electrical energy; the expression "generator" means the dynamo or dynamos or other electrical apparatus used for the generation of energy; the expression "motor" means any electric motor carried on a car and used for the conversion of energy; the expression "pipe" means any gas or water pipe or other metallic pipe, structure, or substance; the expression "wire" means any wire or apparatus used for telegraphic, telephonic, electrical signalling, or other similar purposes; the expression "current" means an electric current exceeding one-thousandth part of one ampere; the expression "the company" has the same meaning as in the —— Tramways Act.

Regulations.

1. Any dynamo used as a generator shall be of such pattern and construction as to be capable of producing a continuous current without appreciable pulsation.*

2. One of the two conductors used for transmitting energy from the generator to the motors shall be in every case insulated from earth, and is hereinafter referred to as the "line"; the other may be insulated throughout, or may be uninsulated in such parts and to such extent as is provided in the following regulations, and is hereinafter referred to as the "return."

3. Where any rails on which cars run or any conductors laid between or within 3ft. of such rails form any part of a return, such part may be uninsulated. All other returns or parts of a return shall be insulated, unless of such sectional area as will reduce the difference of potential between the ends of the uninsulated portion of the return below the limit laid down in Regulation 7.

4. When any uninsulated conductor laid between or within 3ft. of the rails forms any part of a return, it shall be electrically connected to the rails at distances apart not exceeding 100ft. by means of copper strips having a sectional area of at least one-sixteenth of a square inch, or by other means of equal conductivity.

5. When any part of a return is uninsulated, it shall be connected with the negative terminal of the generator, and in such case the negative terminal of the generator shall also be directly connected, through the current indicator hereinafter mentioned, to two separate earth connections which shall be placed not less than 20 yards apart. Provided that in place of such two earth connections the company may make one connection to a main for water supply of not less than 3in. internal diameter, with the consent of the owner thereof and of the person supplying the water, and provided that where from the nature of the soil or for other reasons the company can show to the satisfaction of an inspecting officer of the Board of Trade that the earth connections herein specified cannot be constructed and maintained without undue expense, the provisions of this regulation shall not apply. The earth connections referred to in this regulation shall be constructed, laid, and maintained so as to secure electrical contact with the general mass of earth, and so that an E.M.F. not exceeding four volts shall suffice to produce a current of at least two amperes from one earth connection to the other through

* The Board of Trade will be prepared to consider the issue of regulations for the use of alternating currents for electrical traction on application.

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the earth, and a test shall be made at least once in every month to ascertain whether this requirement is complied with. No portion of either earth connection shall be placed within 6ft. of any pipe except a main for water supply of not less than 3in. internal diameter which is metallically connected to the earth connections with the consents hereinbefore specified.

6. When the return is partly or entirely uninsulated the company shall in the construction and maintenance of the tramway (*a*) so separate the uninsulated return from the general mass of earth, and from any pipe in the vicinity; (*b*) so connect together the several lengths of the rails; (*c*) adopt such means for reducing the difference produced by the current between the potential of the uninsulated return at any one point and the potential of the uninsulated return at any other point; and (*d*) so maintain the efficiency of the earth connections specified in the preceding regulations as to fulfil the following conditions—viz: (i.) That the current passing from the earth connections through the indicator to the generator shall not at any time exceed either two amperes per mile of single tramway line or 5 per cent. of the total current output of the station. (ii.) That if at any time and at any place a test be made by connecting a galvanometer or other current indicator to the uninsulated return and to any pipe in the vicinity, it shall always be possible to reverse the direction of any current indicated by interposing a battery of three Leclanché cells connected in series if the direction of the current is from the return to the pipe, or by interposing one Leclanché cell if the direction of the current is from the pipe to the return. In order to provide a continuous indication that the condition (i.) is complied with, the company shall place in a conspicuous position a suitable, properly connected, and correctly marked current indicator, and shall keep it connected during the whole time that the line is charged. The owner of any such pipe may require the company to permit him at reasonable times and intervals to ascertain by test that the conditions specified in (ii.) are complied with as regards his pipe.

7. When the return is partly or entirely uninsulated a continuous record shall be kept by the company of the difference of potential during the working of the tramway between the points of the uninsulated return furthest from and nearest to the generating station. If at any time such difference of potential exceeds the limit of seven volts, the company shall take immediate steps to reduce it below that limit.

8. Every electrical connection with any pipe shall be so arranged as to admit of easy examination, and shall be tested by the company at least once in every three months.

9. Every line and every insulated return or part of a return except any feeder shall be constructed in sections not exceeding one-half of a mile in length, and means shall be provided for isolating each such section for purposes of testing.

10. The insulation of the line and of the return when insulated, and of all feeders and other conductors, shall be so maintained that the leakage current shall not exceed one-hundredth of an ampere per mile of tramway. The leakage current shall be ascertained daily before or after the hours of running when the line is fully charged. If at any time it should be found that the leakage current exceeds one-half of an ampere per mile of tramway the leak shall be localised and removed as soon as practicable, and the running of the cars shall be stopped unless the leak is localised and removed within 24 hours. Provided that where both line and return are placed within a conduit, this regulation shall not apply.

11. The insulation resistance of all continuously insulated cables used for lines, for insulated returns, for feeders, or for other purposes, and laid below the surface of the ground, shall not be permitted to fall below the equivalent of 10 megohms for a length of one mile. A test of the insulation resistance of all such cables shall be made at least once in each month.

12. Where in any case in any part of the tramway the line is erected overhead and the return is laid on or under the ground, and where any wires have been erected or laid before the construction of the tramway in the same or nearly the same direction as such part of the tramway, the company shall, if required so to do by the owners of such wires or any of them, permit such owners to insert and maintain in the company's line one or more induction coils or other apparatus approved by the company for the purpose of preventing disturbance by electric induction. In any case in which the company withhold their approval of any such apparatus the owners may appeal to the Board of Trade, who may, if they think fit, dispense with such approval.

13. Any insulated return shall be placed parallel to and at a distance not exceeding 3ft. from the line when the line and return are both erected overhead, or 18in. when they are both laid underground.

14. In the disposition, connections, and working of feeders the company shall take all reasonable precautions to avoid injurious interference with any existing wires.

15. The company shall so construct and maintain their system as to secure good contact between the motors and the line and return respectively.

16. The company shall adopt the best means available to prevent the occurrence of undue sparking at the rubbing or rolling contacts in any place and in the construction and use of their generator and motors.

17. In working the cars the current shall be varied as required by means of a rheostat containing at least 20 sections, or by some other equally efficient method of gradually varying resistance.

18. Where the line or return or both are laid in a conduit the following conditions shall be complied with in the construction and maintenance of such conduit: (*a*) The conduit shall be so constructed as to admit of easy examination of and access to the conductors contained therein and their insulators and supports. (*b*) It shall be so constructed as to be readily cleared of accumulation of dust or other *débris*, and no such accumulation shall be permitted to remain. (*c*) It shall be laid to such falls and so connected to sumps or other means of drainage, as to automatically clear itself of water without danger of the water reaching the level of the conductors. (*d*) If the conduit is formed of metal, all separate lengths shall be so jointed as to secure efficient metallic continuity for the passage of electric currents. Where the rails are used to form any part of the return they shall be electrically connected to the conduit by means of copper strips having a sectional area of at least one-sixteenth of a square inch, or other means of equal conductivity, at distances apart not exceeding 100ft. Where the return is wholly insulated and contained within the conduit, the latter shall be connected to earth at the generating station through a high resistance galvanometer suitable for the indication of any contact or partial contact of either the line or the return with the conduit. (*e*) If the conduit is formed of any non-metallic material not being of high insulating quality and impervious to moisture throughout, and is placed within 6ft. of any pipe, a non-conducting screen shall be interposed between the conduit and the pipe, of such material and dimensions as shall provide that no current can pass between them without traversing at least 6ft. of earth, or the circuit itself shall in such case be lined with bitumen or other non-conducting damp-resisting material in all cases where it is placed within 6ft. of any pipe. (*f*) The leakage current shall be ascertained daily, before or after the hours of running when the line is fully charged, and if at any time it shall be found to exceed half an ampere per mile of tramway the leak shall be localised and removed as soon as practicable, and the running of the cars shall be stopped unless the leak is localised and removed within 24 hours.

19. The company shall, so far as may be applicable to their system of work, keep records as specified below. These records shall, if and when required, be forwarded for the information of the Board of Trade.

Daily Records.

Number of cars running.
Maximum working current.
Maximum working pressure.
Maximum current from the earth connections (*vide* Regulation 6 (i)).
Leakage current (*vide* Regulations 10 and 18 (*f*)).
Fall of potential in return (*vide* Regulation 7).

Monthly Records.

Condition of earth connections (*vide* Regulation 5).
Insulation resistance of insulated cables (*vide* Regulation 11).

Quarterly Records.

Conductance of joints to pipes (*vide* Regulation 8).

Occasional Records.

Any tests made under provisions of Regulation 6 (ii.).
Localisation and removal of leakage, stating time occupied.
Particulars of any abnormal occurrence affecting the electric working of the tramway.

PROPOSED REGULATIONS FOR ELECTRIC RAILWAYS.

The foregoing regulations only concern tramways worked by electricity, but as during last session certain Acts of Parliament were granted authorising the use of electric traction on railways to be constructed underground in metal-lined tunnels, the duty has again devolved upon the Board of Trade to prescribe regulations for the prevention of injury to gas and water pipes, and for minimising interference with other electric circuits. In this connection the following draft regulations have been prepared and submitted for the consideration of the Board of Trade:

DRAFT REGULATIONS made by the Board of Trade under the provisions of the —— Railway Act, for regulating the employment of insulated returns, or of uninsulated metallic returns of low resistance; for preventing fusion or injurious electrolytic action of or on gas or water pipes or other metallic pipes, structures, or substances; and for minimising as far as is reasonably practicable injurious interference with the electric wires, lines, and apparatus of parties other than the company, and the currents therein, whether such lines do or do not use the earth as a return.

Definitions.

In the following regulations the expression "energy" means electrical energy. The expression "generator" means the dynamo or dynamos or other electrical apparatus used for the generation of energy. The expression "motor" means any electric motor carried on a train and used for the conversion of energy. The expression "pipe" means any gas or water pipe or other metallic pipe, structure, or substance. The expression "the company" has the same meaning as in the —— Railway Act.

Regulations.

1. Any dynamo used as a generator shall be of such pattern and construction as to be capable of producing a continuous current without appreciable pulsation.*

* The Board of Trade will be prepared to consider the issue of regulations for the use of alternating currents for electrical traction on application. Note.—These regulations only apply to railways constructed underground in metal-lined tunnels.

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2. One of the two conductors used for transmitting energy from the generator to the motors shall be in every case insulated from earth by means of insulators of a strong and durable material so shaped as to offer great resistance to surface leakage, and is hereinafter referred to as the "line"; the other may be similarly insulated throughout, or may be uninsulated in such parts and to such extent as is provided in the following regulations and is hereinafter referred to as the "return."

3. Where any rails on which trains run or any conductors laid within the metal-lined tunnels in which the railway is constructed form any part of a return, such part may be uninsulated. All other returns or parts of a return shall be insulated.

4 When any uninsulated conductor forms any part of a return, it shall be electrically connected to the rails at distances apart not exceeding 100ft. by means of copper strips having a sectional area of at least one-sixteenth of a square inch, or by other means of equal conductivity.

5. When any part of a return is uninsulated it shall be connected with the negative terminal of the generator, and in such case the negative terminal of the generator shall also be directly connected to the iron or other metal plates forming the lining of the tunnels. In each case the connection shall be made through a suitable current indicator.

6. The iron or other metal plates forming the lining of the tunnels shall be so made and connected together as to form a continuous metal tube.

7. Where any pipe is brought into the tunnel from outside, means shall be provided to secure that no portion of the pipe outside the metal tube shall be in metallic connection with the tube or with any conductor of electricity within the tube.

8. When the rails form any part of the return they shall either be electrically connected, at intervals not exceeding 100ft., to the metal tube by metallic conductors which will not be appreciably heated by a current of 100 amperes, or they shall not be in any metallic connection with the metal tube except by means of the connections to the negative terminal of the generator. In the latter case the rails shall be supported by cross sleepers of wood specially prepared to resist the penetration of moisture and the growth of any mould or fungus, and they shall be of such sectional area and so connected at joints and from one line of rails to another, and where necessary to supplementary conductors or feeders, that the difference of potential between the rails and the metal tube shall not in any part and under any working conditions exceed 10 volts. A test of this shall be made at least once in each month.

9. When the return is partly or entirely uninsulated a continuous record shall be kept by the company of the difference of potential during the working of the railway between the points of the uninsulated return furthest from and nearest to the generating station. If at any time such difference of potential exceeds the limit of seven volts, the company shall take immediate steps to reduce it below that limit.

10. Every line and every insulated return shall be constructed in sections, and means shall be provided at or near each station for breaking the connection between sections for the rapid localisation of faults.

11. The insulation resistance of any conductor laid outside the metal tube shall not be permitted to fall below the equivalent of 10 megohms for a length of one mile. A test of this shall be made at least once in each month.

12. The leakage current shall be tested daily before and after the hours of running with the working pressure and duly recorded. Should the amount of this at any time appear to indicate a fault of insulation, steps shall at once be taken to localise and remove it.

13. The company shall, so far as may be applicable to their system of working, keep records as specified below. These records shall, if and when required, be forwarded for the information of the Board of Trade.

Daily Records.

Number of trains running.
Maximum working current.
Maximum working pressure.
Maximum current from the rails to generator.
Maximum current from the metal tube to generator.
Leakage current (*vide* Regulation 12).
Fall of potential in return (*vide* Regulation 9).

Monthly Records.

Maximum difference of potential between rails and metal tube (*vide* Regulation 8).
Insulation resistance of conductors laid outside metal tube (*vide* Regulation 11).

Occasional Records.

Localisation and removal of leakage, stating time occupied.
Particulars of any abnormal occurrence affecting the electric working of the railway.

LEGAL INTELLIGENCE.

THE WINNIPEG STREET RAILWAY COMPANY v. THE WINNIPEG ELECTRIC STREET RAILWAY COMPANY AND THE CITY OF WINNIPEG.

This was an appeal heard a few days ago before the Judicial Committee of the Privy Council from a judgment of the Court of Queen's Bench of the Province of Manitoba, of May 13, 1893, affirming a decision of Mr. Justice Bain. The Lord Chancellor, Lord Watson, and Sir Richard Couch were present.

The Solicitor-General, the Hon. Edward Blake, Q.C. (of the Canadian Bar), and Mr. F. C. Gore were for the appellants; Mr. Finlay, Q.C., Mr. J. H. Munson, and Mr. F. W. Hollams for the Winnipeg Electric Street Railway Company; and Mr. Ewart, Q.C. (of the Canadian Bar), and Mr. Bray for the city of Winnipeg.

The principal question raised in the appeal was whether the city of Winnipeg could validly grant to the Winnipeg Electric Street Railway Company a right to lay down street railways and to run cars within the city in streets already worked by street railways of the appellant company and in streets not yet worked by the appellants, but in which the latter were willing to work. The appellants contend that the city of Winnipeg was precluded from granting competing rights to the respondent company in either case, both by the terms of their statutory powers and also by an agreement made with them (the appellants). The respondents assert that no exclusive right was conferred on the appellants in the matter, and that any contract purporting to have that effect was *ultra vires* and not binding

At the conclusion of the arguments for the appellants,

The Lord Chancellor said their Lordships would not require to hear counsel on the other side. They would deliver judgment on a future occasion.

COMPANIES' MEETINGS.

DIRECT SPANISH TELEGRAPH COMPANY.

The ordinary general meeting of the Direct Spanish Telegraph Company, Limited, was held on Tuesday at the offices, Winchester House, Old Broad-street, Sir John Pender, M.P., presiding.

In moving the adoption of the report, the **Chairman** stated that, after providing for debenture interest, there was a balance to the credit of profit and loss of £4,996. The Falmouth-Bilbao cable became interrupted last August, but it was promptly repaired by the Eastern Company's ship, the "Electra." Satisfactory results had attended the opening last November of the branch office in the Foreign Auction Hall, Covent Garden Market, where a great portion of the fruit trade with Spain was carried on. He would like to have an interview some day with the preference shareholders, as he believed he would be able to show them that it might be better for them to attach their interests more closely to those of the other shareholders and to the general progress of the Company. He believed that with a little judicious handling the position might be made a little fairer all round.

Mr. Edmund Etlinger seconded the motion, which was adopted.

OXFORD ELECTRIC LIGHT COMPANY, LIMITED.

The third ordinary general meeting of the shareholders has been held at the offices, Broad-street, Oxford, under the presidency of the chairman, Sir Henry C. Mance, C.I.E.

The report was as follows: "The directors beg to submit to the shareholders the accounts made up to December 31, 1893, in the form prescribed by the Board of Trade. The revenue account shows a profit of £1,105. 7s, and after providing for the full interest on the debentures issued up to December 31, 1893, there remains a balance of £68. 8s. 5d., which the directors recommend should be carried forward to next account. The balance of £612. 9s. 1d. appearing to the debit of the profit and loss account, 1892, has not been brought forward into the account for the past year, as the contractors under a general settlement with the Company have refunded an amount which the directors have applied to cancelling the preliminary expenses and the balance to debit of the revenue account referred to. During the last year the running of the plant has continued to give entire satisfaction. About 3 000 8-c.p. lamps have been added to the system, and the directors have every reason to hope that the progress during the present year will not be less satisfactory. Since the last report extensions have been made to King Edward's-street, Mansfield-road, St. Giles's, St. Aldate's, and Magdalen College. The total number of lamps installed on December 31 was equivalent to 7,012 8-c.p. lamps. Ten colleges are now connected to the system, and others are expected to instal the light during the present year. 103,895 Board of Trade units were delivered to customers during 1893. The expenditure of coal per unit delivered and metered has been ·718 of a penny, which compares favourably with the results obtained by the majority of central supply stations The directors who retire by rotation are Mr. R. Buckell and Mr. J. L Courtenay, who offer themselves for re-election. Mr. W. S. Carver, the auditor, retires, but offers himself for re-election."

The **Chairman**, in moving the adoption of the report and accounts, said that in consequence of a general settlement with the contractors they had been able to open the accounts of 1893 without bringing forward the adverse balance which appeared in the balance-sheet for the preceding year. The accounts for the year were in a somewhat different form to those previously submitted, and they were now presented exactly in the form prescribed by the Board of Trade. They had still a small amount of debenture capital unissued, but it would be required probably for various extensions which they contemplated carrying out during the year. Considering the short time the Company had been in operation he thought the revenue account shou'd be regarded as extremely satisfactory. They had written nothin;

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off for depreciation, but, on the other hand, there was an item of £396 for the maintenance of machinery and plant, and his impression was that after the expense on the batteries the plant was in better order now than when it was laid down. After providing for debenture interest there remained a balance to the credit of the net revenue account of £68. 8s. 5d., which had been carried forward to the present year. The number of 8-c.p. lamps connected to the system had increased from 4,040 to 7,012, and the number of consumers had increased from 65 to 100. They proposed extending their mains almost immediately to Beaumont-street, Pembroke College, across Magdalen Bridge to the new Magdalen Schools, and the square on the other side of the bridge. The question of extending the mains so as to embrace the residential district in the north of Oxford was receiving serious consideration. The efficiency of the system worked out at about 63 per cent., which compared favourably with other systems. They had not introduced a sliding scale into the town, but they had as a substitute given 5 per cent. discount for cash payments. They had 7,000 lights connected with the mains, whereas their present capacity was at least 15,000, and it was a very hopeful feature for the future that their station could be, at a comparatively small expenditure, so expanded and altered as to bring their capacity up to 30,000 or 35,000 lamps if necessary.

Mr. Bigge seconded the motion, which was carried unanimously.

On the motion of the **Chairman**, seconded by **Mr. Garcke**, Messrs. Buckell and Courtenay were re-elected directors, and Mr. Carver was reappointed auditor. A vote of thanks to the chairman terminated the proceedings.

COMPANIES' REPORTS.

HOUSE-TO-HOUSE ELECTRIC LIGHT SUPPLY COMPANY, LIMITED.

Directors: Henry Ramié Beeton (chairman), William Reginald Davies, Robert Arthur Germaine, William Francis Leese, William Page. Secretary: W. Coupland Weir.

Report of the directors and abstract of accounts for the year ended December 31, 1893.

In submitting to the shareholders the balance-sheet and accounts for the year ended December 31, 1893, the directors beg to report that the revenue account shows a credit balance of £4,231. 4s. 2d., which, with the sum of £525 guaranteed by the Leeds and London Electrical Engineering Company, Limited, referred to in paragraph 7, and the balance, £40. 14s. 3d., brought forward from the previous year, makes a total of £4,796 18s. 5d. After deducting £1,800 for interest paid on £30,000 debentures, it is proposed to deal with the balance as follows:

	£ s. d.
In reduction of preliminary expenses	500 0 0
In reduction of suspense renewals account	100 0 0
Depreciation fund	700 0 0
Dividend of 7 per cent. on £25,000 cumulative preference shares	1,653 10 2
Balance carried forward to next account	43 8 3
	£2,996 18 5

That the Company's business has continued to increase from January 1, 1890, is shown by the table given below.

It is most satisfactory to observe that, whereas the revenue derived from the sale of current shows an increase of £1,421 over last year, the working expenses show a decrease of £19. Since the issue of the last report another engine and alternator have been laid down, bringing the capacity of the station, exclusive of reserve, to 45,000 8-c.p. lamps. The balance of the issue decided on, of £25,000 7 per cent. cumulative preference shares, has been subscribed during the past year. The guaranteed sum of £525 has been credited in account by the Leeds and London Electrical Engineering Company, Limited, for the year 1893, in connection with the business of central-station construction which that company took over. The directors are pleased to report that the application to the Board of Trade to revoke that portion of the Company's provisional order which referred to the northern division of the area of supply has been successful and the Company are now released from their obligation to lay mains in that district. Mr. Robert Hammond has retired from the Board, and has been appointed consulting engineer to the Company. The directors received with regret last year the resignation of their manager, Mr. Albert Gay, on his appointment as resident engineer to the Vestry of St. Mary's, Islington. They have appointed Mr. Henry W. Bowden as chief engineer, and have every reason to be satisfied with their selection. Mr. W. F. Leese and Mr. W. R. Davies retire from the Board by rotation, and being eligible offer themselves for re-election. Messrs. Theobald Bros., Miall, and Co., the auditors of the Company, retire, and submit themselves for re-election.

Revenue Account for the Year ended Dec. 31, 1893.

A.—To Generation of Electricity.

Dr.	£ s. d.	£ s. d.
Coal or other fuel, including dues, carriage, unloading, storing, and all expenses of placing the same on the works	2,838 4 1	
Oil, waste, water, and engine room stores	676 4 3	
Proportion of salaries of engineers, superintendents, and officers	606 8 11	
Wages and gratuities at generating station	1,229 16 8	
Repairs and maintenance as follows: buildings, £10. 1s. 7d.; engines and boilers, £257. 1s. 1d.; dynamos, exciters, motors, etc., £48. 3s.; other machinery, instruments, and tools, £176. 17s. 9d.	492 3 5	
Cartage of ashes	42 7 9	
		5,885 5 1

B.—To Distribution of Electricity.

Proportion of salaries of engineers	35 0 0	
Wages	64 13 8	
Repairs and maintenance of mains of all classes	55 2 7	
Repairs, maintenance, and renewals of transformers, meters, and other apparatus on consumers' premises	19 7 8	
		174 3 11

C.—To Rents, Rates, and Taxes.

Rents payable	214 13 4	
Rates and taxes	244 9 7	
		459 2 11

D.—To Management Expenses.

Directors' remuneration	300 0 0	
Directors' remuneration (special)	200 0 0	
Salaries of managing engineer, secretary, and clerks	325 15 8	
Collector's salary	117 0 0	
Stationery and printing	65 0 11	
General establishment charges	116 12 2	
Auditors of the Company	26 5 0	
Auditors appointed under provisions of the order	30 10 0	
		1,181 3 9

E.—To Law and Parliamentary Charges.

Law charges and construction business expenses	18 14 2

To Special Charges.

Insurances	65 16 5

Sundries.

Interest on open accounts	29 10 3
Bad and doubtful debts account	18 10 2
	7 832 6 8
Balance carried to net revenue account	4,231 4 2
	£12,063 10 10

Cr.	£ s. d.
Sale of electricity per meter at 8d. per B.T.U. (less discounts)	10,633 11 11
Sale of electricity per contract	492 15 5
Rental of meters and other apparatus on consumers' premises	844 3 10
Transfer fees £4 5 0	
Students' instruction 88 14 8	
	92 19 8
	£12,063 10 10

Net Revenue Account.

Dr.	£ s. d.
Interest on debentures paid and accrued to date	1,800 0 0
Amount written off preliminary expenses account	500 0 0
Amount written off suspense renewals account	100 0 0
Depreciation fund	700 0 0
Balance carried to general balance-sheet	1,696 18 5
	£4,796 18 5

Cr.	£ s. d.
Balance from last account	1,002 19 8
Less dividend on preference shares to Dec. 31, 1892	962 5 5
	40 14 3
Profit guaranteed by the Leeds and London Electrical Engineering Company, Limited	525 0 0
Balance brought from revenue account	4,231 4 2
	£4,796 18 5

Date.	Equivalent of 35-watt lamps connected.	Number of houses connected.	Ordinary revenue.	Revenue from construction business.	Total revenue.	Expenditure.	Profits.
			£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
December 31, 1890	13,665	248	5,010 9 2	—	5,010 9 2	4,624 6 5	386 2 9
December 31, 1891	19,388	373	8,328 3 11	—	8,328 3 11	6,077 14 10	2 250 9 1
December 31, 1892	23,700	471	10,688 18 6	525 0 0	11,213 18 6	7,851 19 6	3,361 19 0
December 31, 1893	28,429	599	12,063 10 10	525 0 0	12,588 10 10	7,832 6 8	4,756 4 2

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GENERAL BALANCE-SHEET, DEC. 31, 1893.

Liabilities.	£	s.	d.
Capital—8,322 ordinary shares of £5 each	41,610	0	0
100 founders' shares of £5 each	500	0	0
5,000 preference shares of £5 each	25,000	0	0
	67,110	0	0
300 debentures of £100 each	30,000	0	0
Sundry creditors on open accounts	2,959	2	2
Bills payable	2,397	14	11
Doubtful debt reserve fund	230	0	0
Depreciation fund account	950	0	0
Net revenue account, balance at credit thereof	1,696	18	5
	£105,343	15	6

Assets.				£	s.	d.
Capital account—amount expended for works				77,177	13	0
Construction business development account—as per last balance-sheet	£16,985	14	1			
Less received from Scottish House-to-House Electricity Company, Limited, and further adjustment of accounts	228	2	5			
				16,757	11	8
Preliminary debenture and preference share issue expenses and foundation of business account—as per last balance-sheet	4,744	18	2			
Add sundry outstanding claims paid	10	9	7			
	4,755	7	9			
Less carried to net revenue account	500	0	0			
				4,255	7	9
Suspense renewals account, as per last balance-sheet	300	0	0			
Less carried to net revenue account	100	0	0			
				200	0	0
Stores on hand at December 31, 1893: coal, £90. 12s.; oil, waste, etc., £224. 10s. 3d.; general, £56. 16s. 7d.				371	18	10
Sundry debtors for electricity supplied to December 31, 1893				4,461	12	0
Other debtors				933	2	0
Cash at bankers—Messrs. Glyn, Mills, and Co.	908	16	5			
Parr's Banking Company and the Alliance Bank, Limited (Earl's Court Branch)	247	3	9			
Cash in hand	30	10	1			
				1,186	10	3
				£105,343	15	6

BUSINESS NOTES.

Western and Brazilian Telegraph Company.—The receipts for the week ended March 16 were £3,550.

International Cable Company.—A dividend of 20s. in the £ is announced by the liquidator to the creditors.

Liverpool Overhead Railway.—The traffic receipts of this railway for the week ending 18th inst. amounted to £707.

Leamington.—The tenders received by the Town Council for the telephone have been referred to the General Purposes Committee with power to act.

West India and Panama Telegraph Company.—The receipts for the two weeks ended March 15 were £189 less than for the corresponding period of 1893.

Blackpool.—The new Park Hotel, which Messrs. Lord and Rushton intend to convert out of the old Claremont Hotel, Blackpool, is to be lighted by electricity.

Chelsea Supply Company.—The letters of allotment for the Chelsea Electricity Supply Company, Limited, 6 per cent. preference shares have been posted.

Electricity-Users' Association, Limited.—This Company has been registered with a capital of £2,000 in £1 shares, to insure against all kinds of accidents to electrical apparatus.

Tramcars.—The South London Tramways Company are making experiments in the electric lighting of tramcars. It is said to be probable that the company will introduce this system in all the cars.

Sutton.—The Sutton (Surrey) Local Board invite, by April 4, tenders for the purchase of the powers granted to them by the Board of Trade under the Sutton (Surrey) Electric Lighting Order. Further particulars can be obtained of the surveyor.

Warminster.—A discussion took place at the last meeting of the Local Board with regard to the electric light. Mr. Morgan said he intended consulting an expert to see if something could be done to prevent the dark shadows at present cast by the light.

Fleetwood.—The Improvement Commissioners have referred the question of obtaining complete specification for the proposed electric lighting station in the town's yard to Messrs. Monk and Drummond. The clerk reported last week that the Brush Company were preparing the specification for the works at the town's yard.

Tenders for Boilers.—As stated in our last issue, tenders are required by the 31st inst. for the supply and delivery at their Neepsend works of three Lancashire steel boilers, each 30ft. long by 7ft. 6in diameter, for the Sheffield United Gaslight Company, Neepsend Station.

Tipton.—A plot of land, situated at the factory in close proximity to the railway and canal, has been acquired by Messrs. Buller, Jobson, and Co., electrical engineers, Phœnix Works, Dudley, who, it is stated, propose erecting thereon an extensive galvanising and engineering plant.

City and South London Railway.—The receipts of the Company for the week ending March 18 were £926, against £880 for the same period last year, or an increase of £46. The total receipts for the first half-year of 1894 show a decrease of £12 compared with those for the corresponding period of 1893.

Hove Electric Lighting Company, Limited.—Two fresh issues are announced by this Company, the first consisting of the balance of 3,954 ordinary shares of £5 each, and the second comprising £12,500 in 5 per cent. debentures of £50 and £100 each. In both cases the price of issue is par. The debentures are secured as a first charge upon the whole of the property of the Company.

Arc Lamp Carbons.—Messrs. Ohnemüller and Ulrich, of the Oberfränkische Porzellanfabrik, Küps, Bavaria, inform us that they have appointed Messrs. E. Wallace and Co., of 30-31, Newgate-street, London, E.C., agents for their arc lamp carbons. These carbons are guaranteed by the makers to burn perfectly clean and steady, and they are suitable for both direct and alternating currents.

Oriental Telephone and Electric Company, Limited.—This Company has been registered with a capital of £200,000 in £1 shares to acquire the undertaking of the Oriental Telephone and Electric Company, Limited (now in liquidation). The first signatories to the memorandum of association are: W. Addison, T. Lloyd, G. B. Frost, A. B. Chalmers, B. St. J. Ackers, H. A. Hentsch, and H. Grewing.

Scarborough.—The Electric Light Sub-Committee of the Town Council have had before them a report by Mr. Bernard Drake on the work carried out by the Scarborough Electric Supply Company, Limited, in which some slight alterations were suggested. The town clerk has been instructed to send a copy of the report to the company, and request them to carry out forthwith the recommendations contained therein.

Support for Electric Candles.—Messrs. Faraday and Son have brought out a device the object of which is to afford, by means of triplex springs taking a double bearing, a steady support for imitation candles used in adapting the electric light to sconces and candelabra. The unsightly effect of candles standing at various angles is thus overcome. The candles may be easily removed for cleaning without interfering with the electrical connections.

Dover.—The work of wiring the Town Hall is nearly finished, and the exhibition which the Mayor announced in the Town Council a short time ago will take place during April. The Town Council have received a further letter on the subject of electric light regulations from the Board of Trade, and a copy of the amended regulations as applied to the Dover Company. The alterations referred to the more efficient insulation of the lamp columns.

New Clock at Bankside.—The City of London Electric Lighting Company have just had a clock erected at their new works, Bankside, Southwark. The order to make and fix it was entrusted to Mr. J. W. Benson, of Ludgate-hill and Old Bond-street, who has recently completed a clock which shows time on a 4ft. 6in. illuminated dial on the outside and a 4ft. 6in. copper dial on the inside. It strikes the hours on a 3cwt. bell. All the wheels are of the best gunmetal, and it is fitted with a compensated pendulum.

Waterloo and City Railway.—Applications have this week been invited for 54,000 shares of £10 each of the Waterloo and City Railway Company. The Company was incorporated in 1893, with a share capital of £540,000, and borrowing powers of £180,000, to construct a tunnel line, about one mile and a half in length, commencing under the platforms of the Waterloo Station, crossing the Thames near Blackfriars Bridge, and terminated at a point nearly opposite the Mansion House, without any intermediate station, the motive power to be electricity.

Stirling.—At a meeting of the Stirling Town Council a letter was read from the Board of Trade stating that they proposed proceeding with the application of the Caledonian Electric Supply Company for a provisional order, and presumed the Council's opposition to the application would now be withdrawn. The clerk was instructed to reply that the Council before withdrawing their opposition wished an opportunity of making terms with the company, and a special committee was appointed to watch over the matter in the interests of the ratepayers.

Lighting of Papermills.—An electric light installation has been introduced in the Watchett Papermills, Somersetshire. The proprietors, Messrs. Wansbrough and Worral, entrusted the work of installing the electric light to the Newton Electric Engineering Company, of Taunton. The fixing of the wires and plant has been under the superintendence of Messrs. H. Osborne and A. Miller. The current is generated by a Newton compound dynamo, which is driven by steam, but water power can be utilised when required, and the light is distributed all over the mills. There are installed 155 incandescent lamps.

Weston-super-Mare.—At the last meeting of the Town Commissioners a memorial from local tradesmen and ratepayers was

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read, requesting the Commissioners to put into force the powers obtained for the installation of the electric light. The Chairman said that the time had come when the lighting question should be considered. Their loans would soon be consolidated, and the matter was ripe for consideration. He would suggest that the memorial be handed to an electric light committee, who could report thereon to the Board. After some discussion, an electric light committee was formed to consider the matter.

Refuse and Steam Generation.—The prospectus has been issued of the London Refuse Steam Generator and Electrical Power Corporation, Limited, which has been formed for the purpose of acquiring the rights for London and 20 miles round of working Livèt's patents for destroying town refuse, and for the generation of heat in furnaces (by the utilisation of dust and refuse) for electric lighting and other purposes. The capital of the company is £600,000 in shares of £1 each. The purchase price is £400,000, of which the vendors stipulate for £200,000 in shares, and for the balance in cash or shares, at the option of the directors.

Atlas Carbon Company.—The Atlas Carbon Manufacturing Company, Limited, of 19, Ewer-street, London, S.E., make a speciality of Leclanché batteries, of which they produce thousands weekly. The Company make the battery from beginning to end, and being carbon manufacturers they are able to work economically and ensure quality. The Company supply Leclanché cells, complete, in the porous pot form and in the agglomerate block form; porous pots (charged); agglomerate blocks, battery plates, plain or capped, and carbons of all kinds. Large stocks of the following goods are held at the Company's works: battery glasses, salammoniac, battery manganese, porous pots, zincs, crushed carbon, etc.

Yarmouth.—The Town Council have received 26 tenders for the laying down of the electric light installation, but only six of these were complete tenders. The lowest tender was Messrs. Crompton's, at £12,578. 4s., and the highest Mr. H. South's, at £19,624. The committee accepted the former, and the town clerk has been authorised to fix the corporate seal to the contract. The Surveyor stated at a meeting of the Council last week that the cost of the electric lighting works at the prices of the accepted tenders would be £16,200, whilst the loan sanctioned by the Local Government Board was only for £15,000. The Council resolved to apply to the Local Government Board for sanction to borrow an additional £1,500. The committee's report was adopted.

Electric Cooking and Heating Appliances.—Messrs. Crompton and Co., Limited, recently gave an exhibition of electrical heating and cooking appliances at the Sanitary Institute before the Duchess of Albany and a large company of ladies. Mr. H. J. Dowsing, who had charge of the exhibition, showed electric ovens, hot-plates, radiators, foot-warmers, etc., at work. Her Royal Highness took great interest in the apparatus, and was particularly struck with the perfect cleanliness of the cooking arrangements. She asked various questions with regard to the principles of construction and as to how the heat was obtained. The convenient system of regulating the heat of the ovens was particularly noticed, and the possibility of warming rooms without vitiating the atmosphere by means of electric radiators gave great satisfaction. At the close of the exhibition, her Royal Highness expressed herself as delighted with what she had seen, and personally thanked the demonstrator for the explanations he had given as to the working of the appliances.

New Installations.—Messrs. Gent and Co., of Faraday Works, Braunstone Gate, Leicester, have just completed the lighting of the printing and composing rooms and library of the *Folkestone Herald*. The plant consists of an 8-h.p (brake) Robey gas-engine fitted with balanced crank for steady running and noiseless exhaust chamber, the firm's "high-class" dynamo, and all fittings complete for an output of 80 lights of 16 c.p. Messrs. Gent and Co. have also just finished an installation for Messrs. Jermyn, Smith, and Co., drapers, of Peterborough, where not only are the company's drapery establishments lighted, but also the adjoining shops and a bank. The motive power is provided by a Robey gas-engine, the dynamo being one of the company's "high-class" dynamos. This is the first installation for shop-lighting in Peterborough. The same firm have secured the contract for lighting the Hotel Wampach, Folkestone. This plant will also be driven by a Robey gas-engine. The contract includes a set of accumulators, a dynamo, and all fittings for 150 16-c.p. Edison and Swan lamps, the principal rooms to be provided with elaborate electroliers.

A Cold Galvanising Process.—With the object of cheapening the process of coating iron with zinc and of avoiding the deterioration of the quality of the material which usually follows pickling and hot galvanising, Mr. Cowper-Coles, of 16, Adam-street, W., has invented a process for coating iron with spelter in a cold condition. Messrs. Laird Bros., of Birkenhead, were the first to adopt the cold galvanising process, and erected a plant for the purpose of cold-coating plates up to 18ft. long with zinc. The articles to be so treated are first pickled and then passed through a washing-tank, or oxidising-tank, after which they are removed to the plating-bath by means of an overhead trolley running on rails. To quicken the process, retain a smooth surface, and prevent any reduction in the tensile strength, an electric current is passed through the pickling-tank. Several shipbuilders are now erecting plants capable of dealing with plates 25ft. long, and of coating the frames of small craft, such as torpedo-boat destroyers, after riveting up. As the result of experiments made to ascertain the relative tensile strength, etc., of specimens cut from steel-plate strips, treated by the cold process and by the ordinary hot method, it was found that the elastic stress of the plates zinc-plated was 17·4 tons per square inch, as against 16 5 tons by the old method, the ultimate stress being 26·3 tons and 27·9 tons, and the extension in 10in., 24·9 and 22 6 per cent. respectively. Tests made to determine the adhesion of the zinc plating, as compared with hot galvanising, showed that, whilst in the latter case the coating began to scale at from 57.750lb. to 63,130lb. per square inch, the zinc plating did not scale, but remained intact throughout the experiments. It is claimed that the cold process is quite 40 per cent. cheaper than the hot, and there is no warping or distorting of articles of small section.

The National Telephone Company's Irish Policy.—"In our columns yesterday," the *Irish Times* of Tuesday's date remarks, "Mr. James H. North referred to a 'rather curious departure in the matter of its agreements,' with Irish users of the instrument, by the National Telephone Company. 'Lately the Company has adopted the 1st of January as its gale day, and all recent or new tenancies run from that date. In a circular issued a month or so back, subscribers were informed that on their signing agreements for five years the rents would be reduced to £10 per annum, the reduction to date from January last in all tenancies running from that date, but not to affect other tenancies till the expiration of the present year. Under this rule I and the other tenants whose years began on the 1st October must pay the higher rent for the current 12 months, while a subscriber who only joined on the 1st January last gets the benefit from that day. This, to my mind,' says Mr. North, 'is a palpable injustice.' It is an evidently reasonable protest if the amount involved is small to each individual, and Mr. North's clear and forcible statement was sure to attract notice. To-day, accordingly, Mr. D. O'C. Miley opens up a further departure of the Company which we think more curious still. 'The proposed (diminished) rental of £10 per annum is only to take effect if the subscriber signs an agreement binding himself to continue his subscription for a period of five years.' This agreement, it appears, contains a clause that if, from any cause whatever, the yearly rent is in arrear for a month, or if the subscriber becomes insolvent,' or in any way violates any of the 14 other long provisions of the agreement, the whole £50 shall thereupon immediately become payable as liquidated damages to the Company.' Our second correspondent refuses to sign any such agreement. He has been, along with others, since 1883 expecting a reduction of rate, and instead has this complicated penal arrangement offered to him. The five years' plan, as far as we see, cannot be approved. We should like to hear the grounds upon which it is judged necessary. Unless some very sufficient and satisfactory reasons can be adduced, which it is not possible to imagine, the movement of remonstrance commenced so well by Mr. North in his letter, and seconded as we now state, is sure to grow and extend among the Company's discontented tenants."

Electric Lighting of Derry.—The contractors' test of the electric lighting plant in Derry took place on Saturday evening, when the streets were lighted from seven till half-past ten o'clock. It is not intended to light the city permanently for a week or two yet. Among those who attended were Councillor T. S. Magee, chairman of the Lighting Committee; Aldermen Bell and Johnston; Councillors Turner, Thompson, Brewster, Taaffe, and Young; Prof. Leebody, D Sc.; Mr. H. W. Blake, consulting electrical engineer; Mr. W. J. Robinson, city surveyor; Mr. R. E. Buchanan, C.E.; Mr. William Colhoun; Mr. R. H. Algeo; Mr. Collings, Messrs. Siemens Bros.' engineer; Mr. Mittlehausen; Mr. Clamp, engineer for Messrs. Johnson and Phillips; and several members of the firm of Messrs. Alex. Brown and Sons. The floor of the machinery-hall might be described as one huge mass of solid concrete, the engine foundations, which extend some 9ft. into the earth, reaching halfway across the room, and only separated from the dynamo foundations by the condenser-pipe trench which connects the condensing engines with the water of the river. The same description is applicable to the boiler-house. The chimney is 125ft. in height above the floor-level, besides 20ft of foundation buried in the earth. The projection of the cap at the top is well proportioned and symmetrical. The structure has been pronounced by authorities to be one of the best in Ulster. It is designed to meet the requirement of any extension of the electric lighting scheme which might be carried out in the future. Mr. R. E. Buchanan was the engineer for this part of the work, and Mr. M. M'Clelland was the contractor. On entering the electric light station the first thing that commands attention is the three large powerful steam-engines, which have been entirely made and erected by a local firm—Messrs. Alex. Brown and Sons. Two of the engines were put in motion to drive the dynamos which lighted the city on Saturday evening with successful results. The engines are of a marine type. The fly-wheels are 8ft. in diameter, 24in. broad on face, and weigh about three tons each. On each flywheel there runs two 10in. belts for driving dynamos. All the engines have a separate jet condenser placed below the floor-level, so that at all states of the tide the river water can be used for steam condensation. The engines are controlled by Hartnell governors. The engines are to run at 150 revolutions per minute, and at this speed, with 125lb. per square inch boiler pressure, will indicate about 130 h.p. each, which is about 50 per cent. in excess of what is required. In the erection of the steam-engines in position and in the placing of the dynamos a large six-ton overhead travelling crane, erected by Messrs. Alexander Brown and Sons, was used. The boiler-house contains two boilers, either of which is sufficient to supply steam for the three steam-engines. The boilers are 26ft. long by 7ft. in diameter, made from the best selected boiler steel. The boilers, and all pipes, etc., carrying the boiler pressure, were tested by Messrs. Alexander Brown and Sons, in presence of Mr. Blake, up to a pressure of 200lb. per

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square inch, and all certified as satisfactory. The economiser is placed behind the boilers in a specially-constructed chamber. All the work has been done in the high-class style which characterises the firm of Messrs. Brown and Sons. Messrs. Siemens Bros. supplied the dynamos and cables. There are six of the former, two pairs being used to supply the light and one pair being kept in reserve. The dynamos run at 750 revolutions per minute. There are 160 arc lamps of 2,000 c.p., and these can be added to without requiring extra plant, the engines and dynamos not being fully loaded. The representative of Messrs. Siemens Bros. is Mr. Collins, who has superintended the laying down of the entire electrical plant. He was assisted by Mr. Mittlehausen, of the same establishment. The arc lamps used are of the Brockie-Pell type, of which Messrs. Johnson and Phillips, of Charlton, London, are the sole manufacturers. The present installation in Derry consists of 160 lamps. The ornamental cast-iron carriers used are of Messrs. Johnson and Phillips's own design, and the lamps were put up by the firm's own men, under the supervision of their engineer, Mr. Ernest J. Clamp.

PROVISIONAL PATENTS, 1894.

MARCH 12.

5102. **A new or improved telephonic relay.** George Gillmore, 70, Market-street, Manchester.

5118. **Improvements in and connected with electro-locomotion on railways.** William Edwin Heys, 70, Market-street, Manchester. (Jean Jacques Heilmann, France.) (Complete specification.)

5157. **Improvements in apparatus for indicating the height of fluids in tanks or reservoirs by electricity.** Matthew Mawson and Arthur Stuart, Cornwall House, Humber-road, Blackheath, London.

5158. **Improvements in splice coverings for electric wires.** Thomas Jefferson Dewees, 45, Southampton-buildings, Chancery-lane, London. (Complete specification.)

5164. **Improvements relating to fittings for suspended electric lamps.** Adolph Hoffmann, 18, Buckingham-street, Strand, London.

MARCH 13.

5194. **Improvements in the method of and apparatus for starting and stopping electric motors.** Thomas Reginald Andrews and Thomas Preece, Borough Mills, Manchester-road, Bradford.

5203. **Improved electric-lit sights for night shooting, on sporting rifles and other guns.** Montague Herbert Galsworthy and Sydney Stuart Galsworthy, 33, Gloucester-gardens, Hyde Park, London.

5217. **Improvements in phonographs and appliances connected therewith.** Alfred Charles Brown and George Richard Neilson, 50, Old Broad-street, London.

5223. **Improvements in or connected with electric batteries.** Charles Percy Shrewsbury, Frank Lawrence Marshall, John Cooper, and John Lasky Dobell, 57, Chancery-lane, London.

5243. **Improvements in electric perforating pens.** Aaron Dabney Lewis, 323, High Holborn, London.

5253. **Apparatus for electric lighting, ventilating, etc., by means of storage batteries and dynamos driven from car axles or other power of varying speed.** William Lloyd Wise, 46, Lincoln's-inn-fields, London. (Isaac Newton Lewis, United States.) (Complete specification.)

5254. **Apparatus for electric lighting, ventilating, etc., by means of storage batteries and dynamos driven from car axles or other power of varying speed.** William Lloyd Wise, 46, Lincoln's-inn-fields, London. (Isaac Newton Lewis, United States.) (Complete specification.)

5271. **Improvements in or connected with electric railways.** Edward Holmes Brown, Norfolk House, Norfolk-street, London. (Complete specification.)

5273. **Improvements in closed conduits for electric railways.** Reginald Walter Barker, Monument-chambers, King William-street, London. (The Lawrence Electric Company, United States.) (Complete specification.)

5276. **Improvements in electric railways.** James Fulton Cummings and Eugene Mathew Engelman, 45, Southampton buildings, Chancery-lane, London.

MARCH 14.

5314. **Improvements in magnetic separators.** Septimus Leonard Anderson, Bank-buildings, George-street, Sheffield.

5340. **Improvements in the construction of electrical resistance coils.** John Ambrose Fleming, University College, Gower-street, London.

5359. **Improvements in electrical signalling and in apparatus therefor.** Charles Balbiani, 22, Glasshouse-street, Regent-street, London.

5363. **An improved form of alternating-current dynamo.** Thomas Barnet Grant, 15, George-street, Mansion House, London.

MARCH 15.

5449. **Improvements in connection with alternating-current dynamos working in parallel.** Guy Carey Fricker, 46, Lincoln's-inn-fields, London.

5417. **A method of and apparatus for electrically signalling or transmitting a communication in the event of a fire or conflagration.** James Thomas Cockerill and William Ellis Bennett, 2, Old Market-chambers, Yorkshire-street, Rochdale.

5433. **Improvements connected with the insulation of electric conductors of armatures or other encased, enclosed, or insulated electric conductors from which it is desirable to allow of the transmission of heat.** Henry Edmunds, 47, Lincoln's-inn-fields, London.

5474. **Improvements in electric arc lamps.** William James Davy, 40, Chancery-lane, London.

MARCH 16.

5508. **Improvements relating to the transmission of signals through submarine telegraph cables.** Alexander Muirhead, 124, Chancery-lane, London.

5509. **Improvements in the manufacture of submarine cables.** Alexander Muirhead, 124, Chancery-lane, London.

5531. **Improvements in dynamo supports for portable and traction engines with locomotive-type boilers.** Frederick John Burrell, 18, Fulham-place, Paddington, London.

5537. **Electrical deposition of zinc and alloys of zinc and apparatus therefor.** Richard Heathfield and William Stepney Rawson, 1, Leadenhall-buildings, London.

MARCH 17.

5579. **Improved solutions for the electric deposition, separation, and refinement of aluminium.** John Kirkwood, 87, St. Vincent-street, Glasgow.

5592. **Improvements in counterweights for electric light pendants and other similar purposes.** John Grubb and Wilson Henry Sturge, 12, Cherry-street, Birmingham.

5619. **Improved construction or arrangement of bridge or support for electric wires and in appliances for fixing or holding such wires in place therein.** Hugo Bartels, 166, Fleet-street, London.

5631. **Improvements in and connected with the electric lighting of trains and other vehicles.** Edwin James Preston and Arthur Bernard Gill, 77, Chancery-lane, London.

5637. **Improvements in electric accummulators.** Irénée Chavanne, 6, Bream's-buildings, Chancery-lane, London.

5643. **An improved telephone combination.** Sir Charles Stewart Forbes and the Domestic Telephone Company, Limited, 21, Finsbury-pavement, London.

5647. **Improvements in the manufacture of secondary coils for transformers.** August Schneller and William John Wisse, 46, Lincoln's-inn-fields, London.

5650. **A thermometric circuit closer.** Richard Pearson, 53, Chancery-lane, London.

SPECIFICATIONS PUBLISHED.

1892.

20598. **Electric accumulators.** Téryc and another. (Second edition.)

1893.

5064. **Electric clocks.** Cauderay.

5638. **Electric arc lamps.** Davy.

7782. **Electric cables.** Hardingham. (Felten and Guilleaume.)

8004. **Electromotors.** De Pass. (Johannet and another.)

8315. **Electric switches.** New and Mayne.

9805. **Electric contacts.** Siemens Bros. and Co., Limited, and Jacob.

22765. **Multiple telegraphy.** McCraith.

1894.

57. **Electric motor apparatus.** Johnston and others.

1003. **Electric railways.** Lake. (Johnson and another.)

1417. **Starting electric motors.** Whittingham.

1473. **Dynamo-electric machines.** Lake. (Dieckmann.)

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	2¾
— Pref.	—	2¼
Charing Cross and Strand	—	5
City of London	—	12¼
— Pref.	—	13½
Electric Construction	—	½
House-to-House	5	1⅛
India Rubber, Gutta Percha & Telegraph Co.	10	23½
Liverpool Electric Supply	5	6⅝
	4½	5½
London Electric Supply	5	1
Metropolitan Electric Supply	—	8⅜
National Telephone	5	4⅝
St. James', Pref.	—	8¼
Swan United	3½	3⅛
Westminster Electric	—	6

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NOTES.

Accumulator Works.—These works are to come under the supervision of inspectors appointed by the Home Secretary.

Royal Institution.—On Tuesday next, Prof. J. A. Fleming will begin a course of lectures on "Electric Illumination."

Institution of Mining and Metallurgy.—The president, Prof. A. K. Huntington, delivered his inaugural address last week.

Central London Railway.—The prospectus of the Central London Railway is about to be issued by the Exploration Company.

Explosion at Preston.—An explosion of gas has occurred in connection with the electric light mains of the electric supply company.

Society of Arts.—On Monday next, at 8 p.m., the first Cantor lecture on "Photometry," by Captain W. de W. Abney, C.B., F.R.S., will be delivered.

York.—In the new bank premises of the York branch of the National and Provincial Bank of England, provision is made for both gas and electric lighting.

The Coatbridge Station.—The Coatbridge station of the Scottish House-to-House Electricity Company, Limited, will be set in operation to-morrow (Saturday) by Lord Kelvin.

Electric Ploughs.—It is said that Messrs. Siemens and Halske are experimenting with an electric plough on the estate of Biesdorf, the property of Mr. Arnold von Siemens.

France and New Caledonia.—France has just been placed in direct telegraphic communication with New Caledonia by the completion of the cable between that colony and Australia.

Scarborough.—The theatre at the Scarborough Spa is to be lighted by electricity. The general adoption of the illuminant at the Spa is a matter for the future consideration of the committee.

Lighting of Liverpool Streets.—By the direction of the city engineer, Mr. H. P. Boulnois, two lamps lighted by electricity have been placed at the bottom of London-road at the junction with Lime-street.

International Telegraph Convention.—The British Ambassador in Paris has notified the Government of the French Republic of the adhesion of the English colony of West Australia to the International Convention.

Society of Engineers.—The next ordinary meeting of this society will be held at the Town Hall, Westminster, on Monday, April 2, commencing at 7.30 p.m. A paper will be read on "Gasholder Construction" by Mr. E. Lloyd Pease.

Electric Traction at Dunedin.—Mr. Webb, Melbourne, and Mr. Walker, Government electrician, of Sydney, are to report to the Government on the introduction of an overhead trolley system in connection with the Dunedin tramways.

Dundee Institute of Architecture, Science, and Art.—The third ordinary meeting of the institute for this session will take the form of a social gathering in the Victoria Art Galleries, Dundee, on Thursday next, April 5, at 6.45 p.m.

Electro-Harmonic Society.—The final smoking concert of the season, as stated in our last issue, will take place this (Friday) evening at the St. James's Hall Restaurant, Regent-street, W. The programme, which was given in our issue of the 23rd inst., is an excellent one.

Northern Society of Electrical Engineers.—This society will hold a smoking concert on Monday next, April 2, at the Palatine Hotel, Hunt's Bank, Manchester, commencing at 8 p.m. Members, who may take friends with them, are requested to assist in the entertainment.

Glasgow Corporation Station.—A paper on "The Corporation Electric Light Supply" was read last week before the members of the Institution of Engineers and Shipbuilders in Scotland by Mr. William Arnot, electrical engineer to the Corporation of Glasgow. The paper was illustrated by diagrams.

London County Council.—The Council propose to introduce this session a Bill relating, among other matters, to the expenditure of money on the electric lighting of the Victoria-embankment, the embankment gardens, and Waterloo and Westminster Bridges, and to the purchase of plant for electric light testing.

Telegraphy in the French Soudan.—The telegraph line between Sigueri and Kankan has been completed. This line will be continued to Keruane, and later on to Kissindougou, the most southern French post in the Soudan. A French paper demands a prolongation of the line, which now runs as far as Segu, up to Jenne, Mopti, and Timbuctoo.

Lighting of Tramcars.—The London Tramways Company are making experiments in the electric lighting of tramcars. The company for a few weeks have had the interior of one of their cars fitted with the electric light. Since Thursday of last week they have utilised the current for illuminating the roof of the car upon which the garden seats are placed.

Personal.—The Corporation of Kingston-upon-Thames, Surrey, have increased to £250 a year the salary of their borough electrical engineer (Mr. J. E. Edgcome), and have appointed him advising engineer to the Drainage Committee with regard to the machinery at the sewage works. Lord Kelvin, whose resignation of his Glasgow Professorship was the other day rumoured, has decided to hold his post till 1896, when he will celebrate his jubilee.

Underground Railways in Paris.—At a meeting of the French Council of Ministers, M. Jonnart, Minister of Public Works, presented a scheme for the construction of a metropolitan railway for Paris. The scheme provides for a series of underground lines which will connect the various terminal stations of the great railway lines. It is proposed to ask the Municipal Council of Paris to share with the State the guarantee under which the new railway will be constructed.

Royal Meteorological Society.—The monthly meeting of this society was held last week, Mr. R. Inwards, F.R.A.S., president, in the chair. Mr. W. H. Dines read a paper on the "Relation between the Mean Quarterly Temperature and the Death-rate," and a second paper on the "Duration and Lateral Extent of Gusts of Wind, and the Measurement of their Intensity." A third paper read was "On the Calculation of Photographic Cloud Measurements," by Dr. K. G. Olsson.

Lectures.—Mr. W. B. Sayers has lectured before the members of the Philosophical Society of Glasgow on "Dynamo-Electric Machinery, and Some of its Applications." Current was introduced from the city electric mains into the lecture hall, and used to give demonstrations with a dynamo, a motor, and electric lamps. At a meeting of the Sheffield Junior Engineering Society on Tuesday, a paper on "Gas *v.* Steam Engines for Factories

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and Electric Lighting Stations" was read by Prof. W. H. Watkinson, of the Glasgow and West Scotland Technical College.

Electric Jib Crane.—An electric jib crane has been erected at the Chester Wharf, Pimlico, where Messrs. F. B. Cameron and Co. unload coal from barges in the Thames. The current is supplied from the mains of the Westminster Electric Supply Corporation. Calculations based upon a series of tests with a weight of 15cwt. of coal show that the efficiency of the crane, the maximum lifting power of which is three tons, stood at 78 per cent. This crane, which is capable of unloading about 200 tons of coal per day, was made by Messrs. Wimshurst, Hollick, and Co., of 602, Commercial-road, E.

Explosion at Bournemouth.—An explosion has taken place in a junction-box, and on the fact being reported to the electric lighting company, an examination of a box was made, but there was nothing to account for the explosion. Another box close by was opened, and when the iron lid of this had been removed, a spark at once made the defect visible. The explosion is attributed to an accumulation of gas in the box, the gas being fired by the electric spark. The Board of Trade was communicated with, and Major Cardew, the inspector who reported on a recent mishap in another part of the town, arrived and made an inspection on the spot.

An Exemplary Sentence.—A sentence, which should prove a severe deterrent, was passed at the Liverpool Assizes last week by Mr. Justice Day on Francis M. Conville, who was tried for swindling John Gardner out of over £50. The prisoner was formerly a bill-poster in the employ of a Liverpool quack, and he started in the same line when his former employer left. His chief methods of treatment were bleeding and an alleged electric belt. He charged fees up to 50 guineas, and the police stated that in three months last year he netted £800, and was known to make £3,000 or £4,000 a year. The accused was found guilty, and the judge sentenced him to five years' penal servitude.

Another Earl's Court Exhibition.—It is intended to hold at Earl's Court from May to October an exhibition of British industries. The principal object of the exhibition is to illustrate as far as possible the industries of Great Britain, with special reference to the advance made in methods of production and in new inventions during the past few years. A special feature will be made of the various industries which can be shown in actual operation. The buildings will be lighted by electricity, and the grounds will be illuminated by thousands of electric, gas, and Vauxhall-lights. The exhibits will be divided into seven sections—manufactures, mechanical engineering, machinery and electricity, agricultural, mining and metallurgy, science, fine arts.

Lighting of Suburbs.—The London correspondent of a Glasgow paper states that: "A powerful syndicate is to be formed, with the support of one of the Rothschilds, with the view of applying for and putting into operation provisional orders for lighting by electricity some of the large and fashionable suburbs of London. In the Metropolis there are 13 electric light areas, but only one of these (St. Pancras) is the result of municipal or corporate enterprise. All others are by private companies. A number of these supply residential districts—Kensington, Mayfair, St. James's parish. The others depend on the demand for business premises. The great demand, however, experienced by some of these companies supplying purely residential areas has suggested that the large suburbs would welcome the new light."

Communication between Lightships and the Shore.—In addition to the electrical connection established between the Kentish Knock Light-vessel and the shore, and to which reference was made in our last issue, telephonic communication has been formed between the North Goodwin Light-vessel and Ramsgate. In this case the distance is much shorter than that between the Kentish Knock and the shore, being only a little over five miles; but as this lightship practically commands the Goodwin Sands, her electric connection is likely to prove of much service in affording the means of giving information at the earliest possible moment of casualties in the vicinity of the sands. The arrangements for carrying the electric cable clear of the ship's moorings are in all respects similar to those adopted for the Kentish Knock, and described in our last issue. The electric cable is taken ashore at Dumpton Gap and then connected with the Ramsgate Post Office. The ships engaged in completing this second lightship were the Post Office cableship "Monarch" and the Trinity steamers "Vestal" and "Warden."

Charing Cross, Euston, and Hampstead Railway.—The prospectus is issued of the Charing Cross, Euston, and Hampstead Railway Company, which is authorised by its special Act of Parliament to construct and work an underground electric railway connecting Charing Cross with Euston and Hampstead, comprising a line about five miles in length, commencing in the Strand, at or near Charing Cross, passing underneath King William-street, Charing Cross-road, Tottenham Court-road, Hampstead-road, Haverstock-hill, and terminating at the junction of High-street with Heath-street, in close proximity to Hampstead Heath, including a branch from the Hampstead-road terminating at or near Euston Station, and forming a communication between that station and Charing Cross. Stations will be constructed at or near Charing Cross, Oxford-street, Euston-road, Euston Station, Mornington-crescent, Chalk Farm, Belsize-park, and Hampstead Heath. The issue is now announced of the authorised share capital of £1,416,000 in £10 shares. The application list opened yesterday, and will close on or before Tuesday next for town and country. The prospectus states that it is proposed to equip the railway for a 2½-minute service each way, with a seating capacity of 200 passengers per train, and it is estimated that the profits will be sufficient to pay over 6 per cent. on the share capital.

The Elongation Produced in Soft Iron by Magnetism.—Mr. S. J. Lochner deals with this subject in the *Philosophical Magazine*. He used for his researches an instrument resembling in its essential features a Michelson interferential refractometer of great sensibility, the elongation being measured by means of a mirror, and the limit of sensibility being lower than one-millionth of an inch. He found that the route by which a certain magnetising force had been arrived at affected the amount of expansion for that force, the expansion varying for rising and falling currents in a curve very similar in shape to the hysteresis cycle. His general results may be summed up as follows: They indicate that the expansion is a function of the ratio between the diameter and the length, and that the elongation varies directly as, possibly, the square root of this ratio. Also, that the expansion varies directly as the permeability. That the amount of magnetising force required to produce the maximum expansion, and the point of no expansion, depends on the ratio between the diameter and the length. That there are two maxima—one produced by increasing the current, and another by decreasing the current from the point which produced the first maximum. That the first contact gives more expansion than the second and following contacts; and, further, that these appear to

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disagree among themselves, the expansion falling off with subsequent contacts. The paper is fully illustrated with tables and diagrams.

Lighting of the Houses of Parliament.—Despite the abnormal length of last session, and the consequent brevity of the periods of recess during which alone structural alterations can be carried out in St. Stephen's, the Office of Works succeeded in making considerable progress with the electric light extension during the year 1893-4. This work, which was commenced under Mr. Plunket's *régime*, is now approaching completion. The task of replacing gas by incandescent lamps without causing inconvenience to the army of officials, was one of no small difficulty. So far, the Office of Works have kept well within their estimate of expenditure. It was computed at the outset that the total cost of the installation would be about £12,000. The actual expenditure up to the end of the current financial year is £8,500, of which £1,600 represents the contribution for the last 12 months. The sum set apart for electric light extension in this year's Civil Service Estimates is £1,200. In view of the greater utilisation of the new illuminant, it was only to be expected that the charges for oil lamps, etc., would show a considerable diminution; as a matter of fact, the estimate for the coming year in this connection is £1,250 as compared with £1,375 in the year 1893-4. Curiously enough, there is an increase of £225 in the estimate for the supply of gas to the two Houses.

The Rating of Electric Lighting Undertakings. The financial progress which so many companies are making is beginning to excite the attention and cupidity of the rating authorities, with the result that assessments in some instances of a most unreasonable character are attempted to be put into force. We have previously directed the attention of our readers to this matter, and some further illustrations of the method have come to our notice. The Eastbourne authorities some time ago raised the assessment of the Eastbourne Electric Light Company from £150 to £795. No doubt some increase in the assessment was warranted by the progress the company had made, but Mr. Humphreys-Davies, of the Machinery Users' Association, advised that the large increase was altogether unjustifiable. The result of the appeal has been a reduction to £525, or about two-thirds. In another case, also conducted by the same association, the Preston authorities have now offered to reduce the assessment of the National Electric Supply Company, Limited, from £1,095 to £675, but this offer has been declined, and an appeal to quarter sessions is intended. As Preston is one of the most highly-rated towns in England, the aggregate rates amounting to nearly 8s. in the pound, the importance of the question will be easily seen, for as the rates are the first charge upon the undertaking, each increase of £100 in the assessment practically means adding £1,000 to the debenture debt if the latter can be raised at 4 per cent., or £800 if at 5 per cent.

Competition for Self-Contained Vehicles.—The proprietors of *Le Petit Journal*, Paris, are organising a competition of self-moving vehicles, to take place on June 1 next. The conditions are as follows: (1) the competition is to be international, vehicles of any country being admitted; (2) no condition is imposed relative to the motive power, which may be steam, electricity, gas, petroleum, or anything else; (3) the vehicles must be able to seat at least four people; (4) preliminary and eliminatory trials are to be made before the competition takes place—for the first of these trials the distance is to be 31 miles, to be traversed in three hours; (5) the preliminary trials are to take place on the roads from Paris to Mantes, Paris to Dreux, Paris to Beauvais, Paris to Gournay, etc.; (6) the first trial is to be made on the road from Paris to Rouen, *vid* St.-Germain, Triel, Meulin, Mantes, Vernon, Gaillon, and Pont-de-l'Arche, the distance being 78 miles; (7) the prize is to be given to the horseless vehicle which best combines the conditions of safety, commodiousness, and economy; (8) each vehicle during the preliminary tests is to carry the inventor or his representative, two members of the jury, and a consulting engineer. Applications will be received from competitors up to April 30, accompanied by a short designation of the vehicle and an entrance fee of 10f. (8s.). The first prize, named *Le Petit Journal* prize, will be 5,000f. (£200). There will be four other prizes respectively of the values of 2,000f., 1,500f., 1,000f., and 500f., say, £80, £60, £40, and £20.

Non-Magnetisable Watches.—The importance of non-magnetisable watches has considerably increased since the extensive use of electricity for the purposes of lighting and traction has made a strong magnetic field almost an ordinary incident of daily life. Of course, remarks the *Times*, watches that can be placed upon the poles of a powerful magnet without being affected have been known for some years, but it has not hitherto been found possible to make them go with sufficient accuracy to win a first-class Kew certificate. The hair-spring in such watches has to be made, not of steel, but of palladium—a metal which is so susceptible to variation of temperature as to make their going uncertain. This difficulty seems now to have been overcome by using an alloy of palladium. Messrs. S. Smith and Son, of the Strand, have been able to produce a non-magnetisable watch which has obtained the highest, or Class A, certificate at Kew, with 79·2 marks out of a possible 100, and was awarded the remarkably high number of 18 marks out of 20 for compensation for effects of temperature. Another non-magnetisable watch from the same makers has gained 19 marks out of 20 for the temperature tests, and its certificate is endorsed: "This watch was subjected to magnetic influence in an intense magnetic field, and its general performance was apparently unaffected thereby." The Kew Committee have shown their appreciation of the importance of non-magnetisable watches by instituting a special class for them and constructing apparatus to test them. With reference to this paragraph, Messrs. Curtis and Horspool, of Leicester, write that in October last a non-magnetisable watch made by them obtained a Class A Kew certificate, marked "especially good," with 81·2 marks out of a possible 100. For temperature compensation this watch gained 19·3 marks out of 20.

County of London and Brush Provincial Electric Lighting Company.—As will be seen from our advertisement columns, the County of London and Brush Provincial Electric Lighting Company, Limited, is inviting subscriptions for ordinary shares. The Company, which was registered in 1891 for the purpose of undertaking the supply of electricity in certain districts in London and in the United Kingdom, has obtained provisional orders, which have been confirmed by Acts of Parliament, for the united parish of St. James and St. John, Clerkenwell, the parish of St. Luke, Middlesex, the district of the Wandsworth Board of Works, including portions of Putney, Clapham, Balham, Upper Tooting, Tooting, Brixton-hill, and Streatham-hill, and the parish of St. George-the-Martyr, Southwark. In addition to these districts the Company will undertake the erection and equipment of power stations in provincial towns where municipal authorities have obtained provisional orders for the supply of electricity which they are prepared to transfer to a responsible company. The Company intends to exercise a

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control over the general business and development of the provincial supply undertakings in which it will become interested. It is intended to at once commence work in St. Luke's, Clerkenwell, and in Wandsworth, whilst in the provinces a controlling interest is to be acquired in the local electric supply companies at Bournemouth, Dover, and Canterbury. Moreover, at Shrewsbury, Bedford, Weston-super-Mare, and other towns negotiations for electric supply are proceeding. The directors are Messrs. J. Bevan Braithwaite, jun., W. C. Braithwaite, F. W. Reynolds, Aymor H. Sanderson, F. Evance Savory, R. Percy Sellon, and B. H. Van Tromp. The capital of the Company is £800,000, but the present issue by the Electric and General Investment Company, Limited, comprises £200,000 in 20,000 ordinary shares of £10 each, of which 19,900 are now offered for subscription. The list of subscriptions will open on Thursday next, April 5, and will close at 4 p.m. on *the same day*.

The Pacific Cable Question.—In the course of an article on "The Colonies" the *Times* says the mission to this country of Mr. Robert Reid, the Victorian Minister of Defence, is drawing to an end, and Mr. Reid has expressed himself as on the whole well satisfied with what he believes himself to have achieved. The principal objects of his mission were three in number. One was to endeavour to facilitate the connection of Australia and Canada by means of a Pacific cable. With regard to the cable, initiative taken on the Canadian side and embodied in the proposals of Mr. Sandford Fleming has been met on the Australasian side by the sympathetic vote, recorded at the Postal Conference lately held in New Zealand, in favour of guaranteeing the interest at 4 per cent. upon a sum of £1,800,000 to be devoted to the construction of the cable. In the midst of these evidences on the part of the colonies of a genuine desire to draw the bonds of union closer, the Imperial Government has alone so far made no sign. To judge by its actions the matter appears to be one to which it is indifferent, and some perception of this attitude is to be noted in the developing caution of the colonial Governments. Naturally they desire to know what response they are to expect in the movement towards us. The vote of the Australasian Postal Conference was, in the case of one colony, given subject to the condition that the Imperial Government should join in the colonial guarantee. One of the three points which are to be definitely pressed upon the Imperial authorities is a request that the Imperial Government will consent to join in an Imperial and colonial guarantee of interest to a limited sum for the construction of a Pacific cable. With regard to this request, it may be said that to grant it is little more, in fact, than to make a formal expression of sympathy with the object of the scheme. The sum for which a guarantee of interest is to be asked is not to exceed £1,800,000. This represents at 4 per cent. a total amount of £72,000 a year, for which we are to make ourselves responsible in conjunction with the Dominion of Canada and the seven colonies of Australasia. Suppose that the scheme should be financially a failure and that we should be under agreement to pay in perpetuity as much as one-half of the guarantee, the military advantage alone of possessing a British cable to the antipodes would be worth securing at the price. If the scheme has even a fractional part of the public utility which is attributed to it, the public guarantee will be, after the first year or two, a liability only in name.

Recording Wattmeter for Arc Circuits.—The success which the Thomson wattmeter for incandescent circuits has experienced has prompted the General Electric Company to design a recording wattmeter especially for the measurement of energy used in groups of arc lights in commercial lighting, such as in stores, factories, halls, and the like. This meter, we gather from the *Electrical World*, is the outcome of 2½ years of careful investigation and experiment. Indeed, probably no other meter or instrument manufactured by the General Company has received more careful study than this meter. It is a true wattmeter, modified in its principles only to meet the change of conditions of arc light service. It is similar in construction to the well-known Thomson recording wattmeter, and has the same damping device—a copper disc and two permanent magnets. It has been designed on the lines of an arc lamp, so far as its location, etc., are concerned—that is to say, to be suspended from the ceiling by two brass rods fastened to a simple ceiling-board, and the same object is attained as in the suspension of arc lamps from the ceiling; the meter is inaccessible except to those who understand its manipulation. A special feature is the safety cut-out contained within the cover proper. The meter is designed to close immediately on possible trouble occurring within it, which might result in the burning out or breaking of the circuit. The cut-out serves to short-circuit the meter and cut it out, rendering trouble in the meter impossible. At the same time, it preserves the continuity of the circuit, and permits the lights to burn without interruption, an advantage sufficiently obvious. The connections of the meter are exceedingly simple. The connection blocks are at the top, the wires being brought first to the ceiling-board, then dropping to the meter. The two terminals farthest from the front of the meter are connected to the line through an absolute cut-out, the two front terminals being connected to the lamps in the house. So far as the operation of the meter is concerned, it makes no difference which wire is positive and which negative, though, of course, to have the lamps to burn correctly, attention will have to be paid to this point. No trouble will be caused if the lineman should make a mistake and connect the wires, which should go through the front terminals to the back and *vice versâ*; there will be no short-circuit or burning out. The meter will run backwards but register correctly, subtracting, instead of adding to, the sum on the dial. Careful tests show that the same accuracy can be expected on a minimum load as on a maximum, and this accuracy is of the highest.

Distribution of Motive Power in France.—The Marquis of Dufferin and Ava, in a despatch to the Foreign Office, encloses a report by Sir J. Crowe, commercial attaché in Paris, on the subject of the distribution of motive power to the dwellings of workmen in France. The information supplied by Sir J. Crowe may be summed up as follows: According to the returns, the Nord is still the most important department for motive power, as it utilises 132,000 horse, or nearly one-seventh of the whole power of France. The department of the Seine follows with 86,000 horse, Pas de Calais with 63,000. Next comes the Loire with 48,000; Seine Inférieure with 43,000; Saône et Loire with 42,000; Meurthe et Moselle, 38,000; Vosges, 32,000; Rhone, 26,000; Bouches du Rhone, 22,000. Neither at Lyons nor at St.-Etienne is there any distribution of power by compressed air, nor is there any application as yet at Lyons of electricity, but Lyons is preparing for establishing works on a large scale to produce, by means of a canal, a waterfall capable of yielding a force of 12,000 h.p., to be distributed in the shape of electrical energy in the dwellings of subscribers. Hitherto Lyons has had at its disposal steam motive power equal to 13,000 h.p.; 1,000 h.p. in addition is obtained by gas-motors, but very little of this is at the disposal of weavers, who want motors of small power, and having been unable till now to get them in the town, have been forced to emigrate

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into the country. The promoters of the new canal, who obtained an Act of the French Parliament, hope to be able to meet the wants of the Lyons weavers by distributing, even to one loom, the power which at present is got by hand. They propose to do so by electricity, obtained by means of a weir at Jonage, above Lyons, which is to give the fall and motive power required. At St.-Etienne three electrical companies exist, from which motive power can be obtained. Their operations have been almost exclusively confined to lighting, but the Edison Company has already 28 subscribers, to whom a motive power of 36 h.p. is assigned. The Electric Company of the Loire, with power obtained from a fall of the Loire at St.-Victor, distributes motive power in the three communes of St.-Genest, Roche la Molière, and St.-Rambert. The number of its subscribers is 12, to whom power up to 7 h.p. is supplied. The Electrical Association of Lignon gets its power from the fall of Lignon, in the Haute-Loire, and has two subscribers for 6 h.p. and 2 h.p. in the communes of St.-Manlice and St.-Didier. It is apparent that St.-Etienne is only just beginning to develop what may become a large business in the distribution of motive power.

Electrolytic Action of the Return Current of Electric Railways.—A special report was recently presented by Messrs. G. W. Plympton and F. R. Lee, the board of commissioners of electric subways for the city of Brooklyn, N.Y., to Mayor Schieren regarding the corrosion of water-pipes, gas-pipes, and telephone cables by the return currents from the various electric railway systems of the city. The report is given as an appendix to the annual report of the commission submitted on December 15 last. The commissioners say: "The experience of Brooklyn is not notably different from that of Boston and Cambridge, Mass., Milwaukee, Wis., Columbus, O., Indianapolis, Ind., and Hamilton, Ont. In each of these cities similar corrosion has been detected, and in none is there any doubt as to the cause. It is known to be due to the imperfections of the means provided by the trolley companies for the conveyance of the electrical current back to the generator. It was at first supposed that the rails would be sufficient, but the current declines to take that route exclusively. The remedy of the evil will have been applied when the trolley companies shall have provided an adequate route for the electric current now discharged into the rails. It was at first reasonably supposed that the rails would afford a sufficient path. Upon the failure of this plan a copper connection to carry the current by the joint was tried. In most cases this expedient failed of complete success, except where the copper bond had unusual dimensions." The commissioners then give the result of several ways of connecting rail joints by copper wires, etc., continuing as follows; "A better way to ensure the conduction of the current is, doubtless, to make the car rail continuous by welding. This method will be employed on the new trolley line soon to be built in the southern part of the city. The most complete solution of the problem is afforded by the double trolley by which the return current is provided for by an overhead wire similar to the one for the outgoing current. But it is to be hoped that it will not be necessary to resort to this method." Some notes of experiments obtained through Mr. I. H. Farnham, electrician of the New England Telephone Company, and relating to the early experience in Boston, are then given, the commissioners concluding as follows: "The conclusions fairly drawn from these notes and from our own experience is that considerable injury is being done to underground pipes and cables, and that it will continue along the lines of the trolley roads (except where the elevated railway extends above them) until better methods of returning the current to the generator are put in practice. The electricians of the several trolley roads are fully aware of the situation, and have speedily applied means of prevention in localities where the corrosion had been detected; but it is doubtful if the method of final cure of the difficulty has yet passed the experimental stage."

The Oldham Central Station.—The ceremony of setting the plant in operation has just been performed. The streets provided with the electric light are the chief business streets in the town, and contain also the principal public buildings, Town Hall, art gallery, public library, etc. Steam is provided by two Lancashire boilers working at a pressure of 120lb. per square inch. Coal can be brought into the station either from the Lancashire and Yorkshire Railway, which adjoins it, or from the street, as may be found most convenient. The engine-room adjoins the boiler-house. Four dynamos have been provided, each driven direct by a Willans engine. The total horse-power provided is 320. A switchboard stands at one end of the engine-room, the space beside the engine being utilised for stores, and at the other end of the engine-room is an engineer's room and lavatories, etc. In the space below these offices a condenser and air-pump worked by a separate engine are placed, and there is a reservoir for condensing water between the boiler-house and the railway. The engines are arranged so that they may be worked either with or without condensation. Above the office is additional store accommodation, and above the engine-room is a battery-room, in which is placed a battery of about 60 cells of 500 ampere-hours capacity. The station is so designed and constructed that the offices can be readily removed to its eastern end when extension becomes necessary. The plant mentioned above is sufficient for the simultaneous lighting of about 2,500 incandescent lamps of 8 c.p. each, or their equivalent, ample reserve being provided in case of any machines requiring repair or overhaul. Judging from the experience of other towns, 2,500 lamps alight at one time corresponds to a total of about 5,000 lamps actually installed. As the area to be supplied is a small one and fairly close to the station, and as there will be very long hours during which the amount of lighting will be excessively small, a low-tension system of the simplest possible kind has been adopted—namely, a two-wire system in which the current is distributed at 105 volts. The mains are bare copper carried upon stoneware insulators in concrete troughs or conduits, carried under the footpaths. Where the roadways are crossed, or where there is not room under the footpaths for a concrete conduit, the mains are laid as insulated cable, carried in cast-iron pipes or casings. The conduits are so arranged that fresh mains can be pulled into them as may be required without any opening up of the roads or footways beyond the lifting of the covers upon the manholes or service boxes. The system of supply is arranged throughout so that at any future time it may be possible to change it into a three-wire system with a minimum of alteration, and without pulling up the footways or roadways. The batteries will be used partly as reserve, but mainly for the purpose of supplying current during the hours of minimum demand, which in a place like Oldham will often be very long. The batteries will be charged by the dynamos during the hours when they must in any case work to supply current to the circuits. By allowing them afterwards to discharge, the whole station can be shut down at night, and often in the morning also, so as to economise expenditure in wages and also in fuel.

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ELECTRIC LIGHT AND POWER.

BY ARTHUR F. GUY, ASSOC. MEM. INST. ELECTRICAL ENGINEERS.

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(Continued from page 344.)

THE ELECTROMOTOR.

It is useful to have a few of the most characteristic features of motors collected together, so that the different conditions of working that there are between a shunt and series wound motor may be easily perceived. The following refer to motors that are run from off constant-pressure mains.

The Shunt-Wound Motor (1) can be used only on a constant-pressure circuit; (2) the current in the field coils remains constant whatever the speed or the load may be; (3) the current in the armature coils decreases as the speed increases, or as the load decreases; (4) the torque or pull of the armature is proportional directly to the current in the armature; (5) the speed remains nearly constant with varying loads; (6) not suitable for starting with dead load on, or for mounting a grade..

The Series-Wound Motor (1) can be used on either constant-pressure or constant-current circuits, but chiefly is used on the former; (2) the current in the field coils

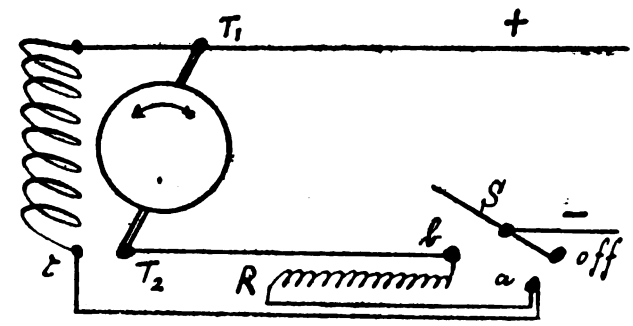

Diagram I.

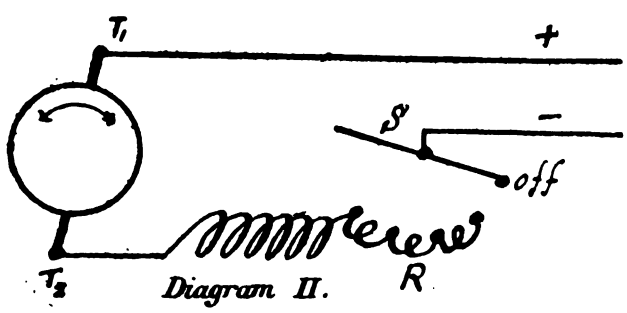

Diagram II.

FIG. 43.

decreases when the speed increases, or when the load decreases; (3) the current in the armature coils decreases when the speed increases, or when the load decreases; (4) since the same current flows through both field and armature coils, therefore the torque of the armature will vary (within certain limits) with the *square* of the current flowing; (5) the speed will vary inversely as the load; (6) suitable for starting with dead load, or in mounting grades.

The E.M.F. that is developed by either a dynamo or a motor is proportional to the speed of the machine, and the strength of the current in the armature coils measures the amount of pull to which the armature is subjected. The product of pressure into current gives electrical power, and, similarly, the product of speed and pull gives mechanical power, so that generally, and in particular with reference to series-wound machines, pressure may be said to correspond with speed and current with mechanical pull. In the case of a dynamo, it is the armature current that strives to drag round the magnetic field in which it revolves; and in the case of a motor, it is the magnetic field that exerts a pull on the armature current and so causes the armature to revolve. The torque of a revolving shaft is obtained by multiplying the pull by the radius of the shaft, and the power transmitted by the shaft is obtained by multiplying the pull in pounds by the peripheral speed in feet per minute. Thus, if P be the force or pull acting on the shaft, and r be its radius in feet, and n = the number of revolutions per minute, then $P \times 2\pi r n$ = foot-pounds of work done per minute, and dividing by 33,000 gives us the horse-power.

Starting and Stopping Motors.—In starting electromotors, a little more caution is required than in starting dynamos, if such a statement can be made; the reason for this is that the armature coils may get badly burnt if the requisite starting resistance is not operated in the right way. If by accident, however, the supply current is switched right on to the armature on starting the machine, it will be found that the safety fuse will blow before any serious damage will be done; but that is not the only thing that will happen. A short-circuit of this kind will always burn or damage the commutator and brushes to a greater or lesser extent, according to whether the fuse is quick-acting or not. Diagram I. of Fig. 43 illustrates a common way of connecting up a shunt-wound motor on to a constant-pressure circuit, the motor being belted to a ventilating fan, which it drives at a constant speed.

The starting resistance is made of spirals of iron wire mounted on an iron frame. This resistance is indicated by R in the diagram. On the top of the frame is the switch, S, having three contact studs. The first stud is marked "off," and the switch is shown in that position. The stud *a* goes to the negative end of the shunt coils, denoted by the letter *t*, this end of the shunt coils being separated from the negative brush. The stud *b* is connected to the negative brush by means of the terminal T_2. The positive main of the supply circuit is joined on to the positive terminal, T_1, while the negative main is joined on to the switch, S, the resistance, R, being connected across *a* and *b*. There are thus three terminals in the motor—two large ones to which the positive and negative brushes are connected, and one small one to which the negative end of the shunt coils is attached. Having oiled up the machine and set down brushes with a slight *backward* lead, it can be started by moving the switch on to stud *a*; this inserts the resistance, R, in the armature circuit, and connects up the shunt coils direct to the supply mains, so then the field current is at a maximum, while the armature current is large, yet reduced to safe limits. At the end of a few seconds the motor has got up a good speed; then the switch is moved on to stud *b*. This cuts out the resistance in the armature circuit, but at the same time inserts it in the field circuit, thus allowing the armature current to increase and decrease the field current. The motor now quickly arrives at full speed, and in so doing the back pressure generated allows only a small current to flow, sufficient to enable the motor to do its work. When stopping the motor, the switch can be at once thrown back to the "off" position.

Diagram II. shows the connections for running a series-wound motor off constant-pressure mains. The motor is started by inserting the whole of the resistance, R, into the motor circuit; then, as it gets up speed, the resistance is gradually taken out by moving the switch forward. The more the resistance that is taken out, the faster will the motor run. To stop the motor, gradually insert the resistance again.

(To be continued.)

CENTRAL-STATION WORKING WITH GAS-ENGINES AND ACCUMULATORS.

Some little time ago (see the *Electrical Engineer*, 8th December, 1893, p. 533) we touched upon the question of employing gas-engines and accumulators for central-station work, and dealt briefly with the manifest advantages that are obtained in this way with regard to levelling down the peak in a daily load diagram, since the generating plant may not only be worked almost continually at maximum output, but is, in addition, of smaller capacity and consequent first cost. One considerable difficulty, however, lying in the way of any extensive adoption of this otherwise excellent system is that the size and power of gas-engines have hitherto been rather limited, involving thereby the use of inconveniently small station units. This objection seems now to be overcome, or is in process thereof, and the

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system generally is being advocated with great warmth in many quarters. Amongst these, as might be expected, perhaps, from a business point of view, the accumulator-makers are prominent, and we note that one of them, the Accumulatoren-Fabrik Company, of Hagen, Westphalia, has gone to the length of issuing a pamphlet dealing with the subject, and containing a number of illustrations and details, some of which we reproduce herewith.

Speaking generally upon the subject, it is, of course, well known that the daily external load of any electric lighting station varies enormously, the heavy output being really only required for two or three hours, at say 6 o'clock p.m., whilst all the rest of the day the plant is nearly idle. In the illustration appended (Fig. 1) the ordinary

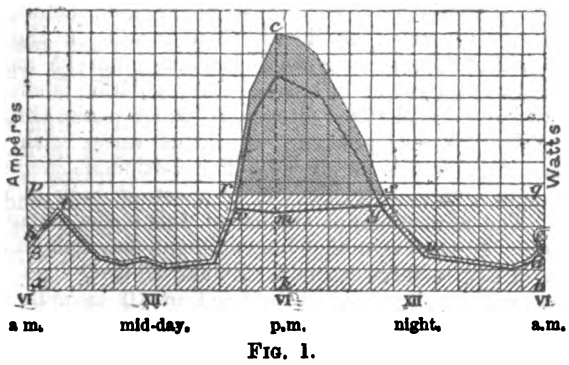

Fig. 1.

load curves are shown in the usual way with a peak reaching its maximum towards 6 p.m. The plant must, of course—in a direct-running station—be equal to the maximum output, shown by the ordinate, ck. By employing accumulators, however, the total capacity of the generating plant at work may be reduced to an amount represented by the ordinate, pa; the plant being driven continuously at full load, so that its output curve is a straight line, $prsq$. The surplus energy stored up at times of light load—from p to r and from s to q—is drawn upon during the time—from r to s—when the load is supernormal.

The Hagen Accumulator Company has followed this plan in drawing up several schemes for town-lighting; these are based upon the use of sub-stations of various sizes and capacities, and in each case estimates are given of the amounts necessary both for capital expenditure and working costs. Some brief notice of these schemes may be taken with advantage.

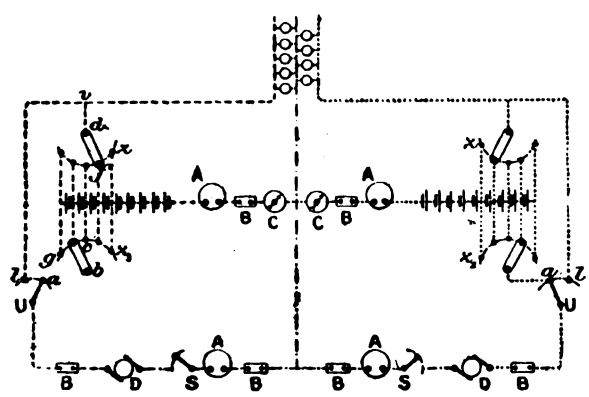

Fig. 2.

One of them provides for the erection of two sub-stations, in any specified district, each of 240 h.p. capacity. For this output three gas-engines would be erected, of 120 h.p. each. Two are supposed each to drive a continuous-current generator, whilst the third is held in reserve. The number of lamps which could be incandesced at the same time from such a station would amount to 7,570, each giving, that is, 16 c.p. at 50 watts. The two stations, therefore, could together run 15,140 such lamps; or assuming not more than two-thirds alight at once out of the total installed, at least 22,710 lamps could be wired. The maximum radius of distribution of each sub-station is given as being about 800 yards, with a working E.M.F. of 200 volts on the three-wire system, and allowing for a drop of 10 per cent. in the voltage owing to line resistance.

The three generating dynamos are of shunt-wound type, giving 697 amperes at 110 volts, and made to charge two batteries of accumulators with a capacity of 4,628 ampere-hours, the rate of charge being 662 amperes and of discharge 1,060 amperes. Figs. 2 and 3 represent the arrangement of distribution adopted with two and three generating units respectively; the methods used are so sufficiently clear from the illustrations that descriptive details are almost unnecessary.

The estimates drawn up by the Hagen Accumulator Company for financial outlay required upon a project of the type detailed herein are divided into four groups, showing respectively the capital outlay, working expenses,

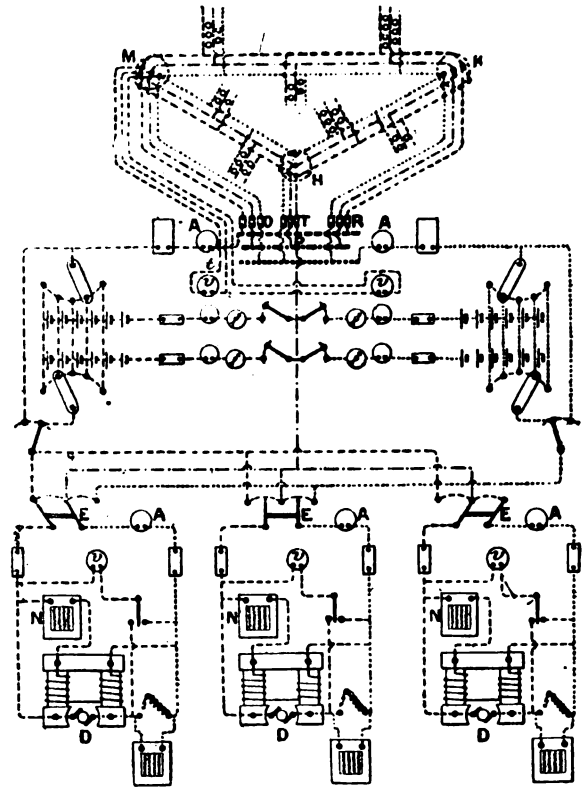

Fig. 3.

probable revenue, and the resulting net profits. In detail they are roughly as follows:

A.—Capital Outlay.

Land and buildings	£7,110
Gas-engines	8,167
Dynamos	5,099
Accumulators	15,682
General station work—switchboards, lighting, etc.	5,775
Distributing mains	31,829
Miscellaneous	350

B.—Working Expenses.

Salaries and wages	1,095
Gas (650 litres per horse-power hour)	2,584
Oil and acid	250
Repairs	280
Miscellaneous	911

C.—Working Results.

Output of electric energy	567,750 kilowatt-hours.
Receipts, at the rate of 10d. per kilowatt-hour, less 5 per cent. discount	£21,574
Total expenditure, allowing 1½ per cent. on buildings, 7½ per cent. on plant, and 3 per cent. on mains, for sinking fund	9,138

From these figures it is stated that with a sinking fund of 4 per cent., and allowing for 3½ per cent. interest, the net profit is 13 per cent. and 9 per cent., according to the price obtained per unit of energy distributed.

SWITCHING GEAR FOR DIRECT AND ALTERNATE CURRENT DYNAMOS.

In the course of the description given in our last issue of the new central station of the Sheffield Electric Light and Power Company, reference was made to the automatic switching gear and electrical governor carried by each

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exciter and to the synchronising pillars (one of which is provided for each alternator), which are equipped with complete switching gear. We now proceed to describe and illustrate these devices which have been invented by officials of the Brush Electrical Engineering Company, Limited. Fig. 1 shows the automatic switching gear devised by Mr. Raworth for use with continuous-current dynamos or exciters. It is applicable in all cases where two or more continuous-current dynamos or exciters are arranged to work in parallel on a common circuit. The apparatus consists of a cast-iron pillar which carries the switching gear and instruments, which are usually an ammeter and a voltmeter. The switch closes automatically when the dynamo attains a voltage equal to that existing in the station mains, whilst it opens automatically when the dynamo ceases to generate current. In order to bring another dynamo into circuit, a weighted lever is fixed up and the engine started. To take a dynamo out of circuit steam is shut off. This switch pillar is placed near the dynamo so that the instruments may be in the view of the attendant in turning on steam. It is claimed that this automatic switching gear entirely prevents accidents from (1) closing switch when dynamo is unexcited or not giving full E.M.F., from (2) closing switch when polarity of dynamo is reversed, and (3) from the current coming back on dynamo and burning down the fuses.

FIG. 1.—Automatic Switching Gear for Direct-current Dynamos.

FIG. 2.—Interlocked Switching Gear for Alternators Working in Parallel.

In Fig. 2 is represented interlocked switching gear devised by Mr. Raworth for use with alternators working in parallel. This apparatus greatly facilitates the working of alternators in parallel, and its general appearance is shown in the illustration. It will be seen that the main switch lever is in the middle, the field switch on the left, and the synchroniser switch on the right. The interlocking gear is arranged so that the main switch cannot be closed until the field switch is closed and the field fully excited, also not until the synchroniser switch is closed. When the main switches are closed the field switch cannot be opened, and the main switches are locked by shutting off the synchroniser switch. The main switches break through water and oil, and are practically sparkless under all conditions. The complete apparatus includes two main switches, one field switch, one synchroniser switch, one synchroniser, one synchroniser voltmeter and two lamps, one main voltmeter, one main ammeter, and one field ammeter. It is claimed that this interlocked switching gear entirely prevents accidents from (*a*) closing main switch when the alternator is unexcited or not giving full E.M.F., and from (*b*) the opening of the field switch when the main switch is closed.

Another invention of Mr. Raworth comprises interlocked switching gear for main feeders for continuous or alternating currents. This apparatus, which is shown in Fig. 3, takes the form of a cast-iron pillar which carries the main switches, fuses, ammeter, and voltmeter, regulating gear, and interlocking machinery. In the base of the pillar, where the leads enter, there is a switch for disconnecting the upper part of the pillar and for establishing the circuit, in order that the instruments, fuses, and switches may be examined and repaired without cutting off the feeder. There are three fuses fixed on the top of the pillar, any one of which may be put in circuit by turning the right-hand handle, but this handle cannot be moved unless the main switch be open. Double-pole switches are fixed below the fuses, and are actuated by the central handle, which is locked by a trigger, which must be released before the switch can be opened or closed. The handle on the left actuates the disconnecting switch, but it cannot be moved unless the main switch be open. The regulation is effected by two hand wheels fixed on a shaft, which passes through the pillar. The regulating apparatus varies with the system of generation employed. For continuous current it consists of a variable resistance, or a set of back E.M.F. cells. The advantages of the use of this feeder pillar are obvious. In the event of a fuse failing, a new one can be put in circuit in three seconds. Should all three fuses fail, a new set can be inserted by hand in 10 seconds. By means of the disconnecting switch any part of the gear can be examined and repaired without any possibility of shock. As the handles are all interlocked no mistakes can be made.

Among other inventions brought out by Mr. Raworth

FIG. 3.—Interlocked Switching Gear for Main Feeders.

may be mentioned a return-current fuse, for use with alternators in parallel, and a universal electrical contact. The former renders the parallel working of alternators perfectly safe, because the fuse will melt only with return current—that is to say, the fuse cannot be melted whilst energy is being transmitted from the alternator to the mains, but should the alternator from any cause fail to give its full E.M.F. the fuse will immediatly act and cut it out of circuit. The importance of this invention cannot be over-estimated, as with plain fuses the possibility of a total extinction is always present. For instance, if three alternators be working in parallel and one of them fail, then the other two have to supply current for the outer circuit and sufficient additional current to burn down the fuses of the disabled alternator. Under these conditions all the fuses would go simultaneously, or the fuses of the two working alternators might melt without cutting off the disabled alternator. With the new return-current fuse this cannot happen, as it will not act with excess current in the right direction, but only with current in the wrong direction. The principle of the return-current fuse is as follows: two paths are provided, one through the fuse and the other through an accelerator, which gives the current a bias to

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select the latter path, but the accelerator has a contrary effect on a return current, forcing it through the fuse. With regard to the universal electrical contact, this presents large surfaces of contact which remain parallel or at the same angle to each other under varying degrees of pressure. The contact-piece is a casting, and is made for use with bar or plug connecters, either parallel or taper. For taper connectors the contact surfaces are arranged at such an angle that the bar or plug will stick between the contact faces, but may be removed by the exertion of a very slight force. The surface of contact is fully four times the sectional area of the metal. Sparking contacts are provided for preventing deterioration of the faces. The contact-pieces are standardised for 250, 500, and 1,000 amperes, each having a large margin.

The Brush Electrical Engineering Company have also introduced an automatic transformer switch invented by Mr. Mordey. This switch has been designed with the view to avoid loss of power during the daytime or periods of light load by automatically removing transformers from circuit when not required for use. It is of very simple and safe construction, and has been developed with a special view to being left for long periods without attention, and having been subjected to long and severe tests is recommended to central-station engineers. The Brush-Geipel automatic regulator is another invention, being a development of the well-known combination of the Brush automatic regulator and Geipel relay. In this improved form of the regulator the variable shunt resistance consists of a pair of carbon plates immersed in water to an amount depending upon the resistance required. The plates are hung from a lever, the movement of which is controlled by an electromagnet receiving its impulses through the relay. The movements of the lever vary the extent of immersion of the plates and produce the required regulating effect in the fields of the dynamo. The apparatus is now made for use with all standard sizes of Brush dymamos. It is very simple, is adjusted without difficulty, and is easily kept in order.

Mr. Mordey has also invented automatic rocker gear for Brush dynamos. This is intended to take the place of the ordinary hand-adjusted rocker used for carrying the brushes of the Brush dynamos. It is controlled by an electromagnet in the regulator circuit, and is moved forward or backward according to the load. For instance, if the number of lamps on the circuit of the dynamo be altered, or if the speed of driving it be varied from any cause (the current being maintained constant by the Brush-Geipel regulator), by this new device the brushes are brought into the position of best collection. This movement has hitherto been done by hand. This rocker is useful, not only in cases where the load or speed is subject to variation, but also where the number of lamps is fixed, as it effects the small variations of position, which even in this case are desirable, and so lessen the wear of the commutator and the amount of attention necessary.

POLYPHASE TRANSMISSION.*

BY CHARLES F. SCOTT.

Alternating-Current Problems.

When alternating current was introduced for lighting it presented many new problems to the electrical engineer. Numerous difficulties and dangers were predicted by the theorist, but in ordinary service most of these have fortunately lain dormant. These difficulties are apt to appear, however, when alternating-current work is attempted on a large scale. The introduction of larger units, heavier currents, higher potentials, or power service are apt to increase the effects of self-induction and capacity so that they will now demand careful consideration. The impetus which electrical engineering is receiving from the introduction of the polyphase system, which brings with it large units and long distances, naturally directs attention to the general problem of alternating-current transmission and distribution.

* Paper read before the National Electric Light Association, Washington.

A complete and exhaustive solution of this problem is by no means a simple one, and the attempted solutions generally lead to formulæ and diagrams which are possibly even more perplexing than the phenomena. If even the electrician who devotes all his energy to new problems can scarcely keep abreast of the times, it is not surprising that the practical engineer and station manager become perplexed and confounded at the apparently erratic phenomena observed in practice or described in print. Theoretical articles appear on variation in wave form, harmonics, so-called Ferranti effects, increased resistance in conductors with alternating currents, hysteresis, peculiar magnetic

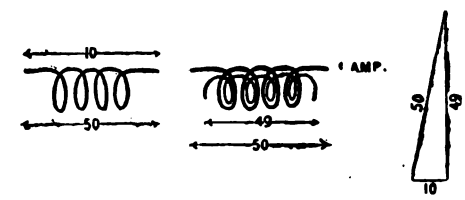

Fig. 1A. Fig. 1B.

circuits, resonance, oscillations, lag, capacity, self-induction. Many of these articles, although evidently intended to be of service in engineering, show apparently no adequate appreciation of the practical bearing and relation of the subjects treated. Consequently, the average engineer becomes bewildered and perplexed, and concludes that theoretical explanations are of little value to the practical man. There are, however, many points of great practical importance which admit of fairly simple statement and explanation. The particular element to be considered in the present paper is the transmission circuit.

Experiments Illustrating Self-Induction.

One of the fundamental characteristics of alternating-

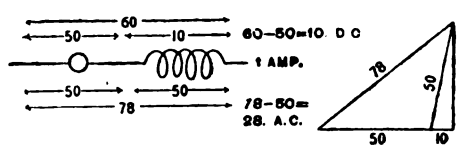

Fig. 2.

current working is self-induction. The effect of self-induction is most readily shown by a simple experiment. A wire having a resistance of 10 ohms may be wound in a coil. Ten volts will send a continuous current of one ampere through this coil. An alternating current of a certain frequency will require 50 volts for producing one ampere through the same wire (Fig. 1A). In the diagrams the numbers above the circuit are for continuous current, and those below are for alternating current. If a one-ampere 50-volt lamp be placed in series with the coil and a current of one ampere be passed through the two in series, the E.M.F. required for continuous current is 10 volts on the coil and

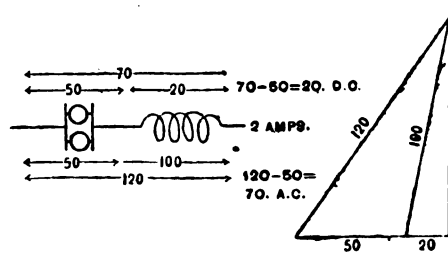

Fig. 3.

50 volts on the lamp, or 60 volts across the circuit, and the E.M.F. required for alternating current is 50 volts across the coil and 50 volts across the lamp, which gives, not 100 volts, but 78 volts measured across the two in series (Fig. 2). If two lamps be placed in multiple and connected in series with the coil, two amperes will require for continuous current 20 volts on the coil and 50 volts on the lamps, or 70 volts across the circuit. For alternating current the E.M.F. on the coil is 100 volts, and on the lamps 50 volts, and on the circuit across the two in series the E.M.F. is 120 volts (Fig. 3).

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The two lamps which are in multiple may be placed in series with a second coil so proportioned that an E.M.F. of 50 volts will send one ampere alternating current through the combination, and a continuous current of one ampere would be caused by 35 volts. This combination may be treated as a unit, and may be used to replace the single lamp in the above test (Fig. 2). If this combination be placed in series with the first coil, the E.M.F. required for sending the continuous current through the circuit will be 10 volts on the coil and 45 volts on the circuit. If the alternating current of one ampere be sent through the

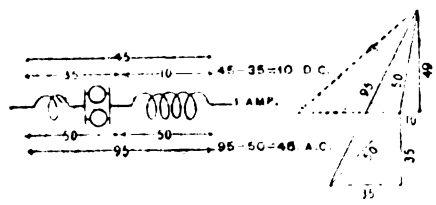

FIG. 4.

circuit, 50 volts will be required across the combination and 50 volts across the coil, the same as with the single lamp, but the E.M.F. across the circuit is no longer 78 volts, but has increased to 95 volts (Fig. 4).

The important facts to be noted in these experiments are (1) that the sum of the alternating E.M.F.'s on the elements in series is greater than that required on the terminals; (2) that the alternating E.M.F. for supplying the lamps in series with a coil is greater than the continuous E.M.F.; and (3) that the difference between the two becomes greater as the number of lamps is increased (Figs. 2 and 3). It is also to be noted (4) that if the same alternating current be supplied through a coil, first to a lamp alone, and then to a combination including lamps and a coil, a higher E.M.F. is required when the combination is used (Figs. 2 and 4).

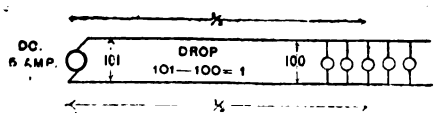

FIG. 5.

These relations, which seem rather perplexing, may be illustrated in a very simple way by diagram. In the case of the coil alone, in which 50 volts are required for producing one ampere alternating current and 10 volts for one ampere continuous current, these two E.M.F.'s may be represented by the hypothenuse and one side of the familiar right-angle triangle. The remaining side represents the counter E.M.F. in the coil. If a second wire had been wound in this coil in parallel with the first, it would be found that when one ampere is passing there is an E.M.F. on the terminal of the second, or idle wire of 40 volts (Fig. 1B). This E.M.F. is caused by

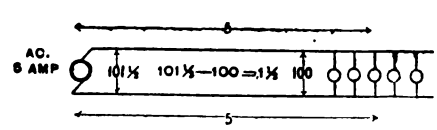

FIG. 6.

the field produced by the alternating current. An equal E.M.F. is, of course, induced in the wire carrying the current, as the two wires occupy virtually the same position. This counter E.M.F. is seen to correspond with the third side of the triangle. Suitable measurements would show that this counter E.M.F. occurs later than the current through the coil, and that its maximum value occurs when the current is passing through its zero. This relation is shown in the diagram by the 90deg. relation of the lines representing counter E.M.F. and the volts required for sending continuous current through the line.

SELF-INDUCTION IN CIRCUITS.

An ordinary circuit may be considered as a choke coil in which there is a single turn. The action in this case is very similar to that illustrated above with a coil of many turns. The effect of self-induction, in a circuit, may be most readily understood by some simple diagrams. A current of, say, five amperes is delivered at 100 volts over a circuit of one-fifth of an ohm resistance. The self-induction of the circuit is such that five amperes generate a counter E.M.F. of 10 volts. Both continuous and alternating currents are used, and the generator E.M.F. is in each case adjusted to give 100 volts at the load.

The load consists first of five incandescent lamps. A coil of high self-induction is then added, which increases the current from 5 to 5·1 amperes. One of the lamps is then cut out and replaced by coils of such a self-induction as to give a total of five amperes. Then all the lamps are cut out, and coils substituted of such a number as to take five amperes at 100 volts. The E.M.F. required on the generator and the resulting drop, or difference of E.M.F. at the

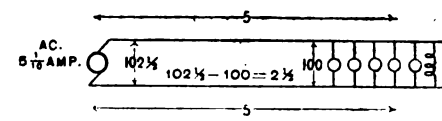

FIG. 7

dynamo and at the load, are given in the diagrams and in the following table:

	Continuous current.	Alternating current.			
	Fig. 5.	Fig. 6.	Fig. 7.	Fig. 8.	Fig. 9.
Current in line	5	5	5·1	5	5
,, ,, lamps	5	5	5	4	0
,, ,, coils.....	0	0	1	3	5
E.M.F. on load..... ...	100	100	100	100	100
,, ,, line	1	10	10	10	10
,, ,, generator ...	101	101·5	102·5	106	110
Drop—total	1	1·5	2·5	6	10

It is to be noted that with exactly the same circuit for supplying five lamps with the same amperes at the same E.M.F., there is an increase of drop between generator and load when continuous current is replaced by alternating current. This drop is much less than the volts required

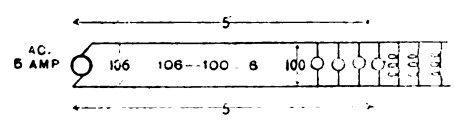

FIG. 8.

for sending the alternating current through the line, and it, moreover, increases enormously as the load becomes even slightly inductive. Thus, when the current is increased only 2 per cent. (from 5 to 5·1 amperes, Figs. 6 and 7), by the addition of inductive load to the lamp load, the increase of drop due to self-induction is increased from ½ per cent. to 1½ per cent., or an increase of threefold. When the load consists of four lamps, and coils are added in multiple to take a total of five amperes, or the same as that taken by the five lamps from the generator, the drop is four times the drop when five lamps alone are in circuit. If the remaining four lamps be re-

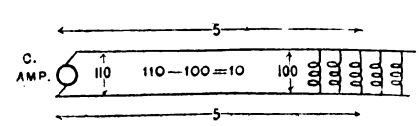

FIG. 9.

placed by coils, the drop does not increase in proportion, but from 6 to only 10 per cent. The effect, therefore, of a slight self-induction in the load causes a much greater proportional drop than the presence of a large self-induction. A counter E.M.F. of 10 per cent. is not at all likely to occur in a 100-volt line carrying small current. The figures given, however, serve as an illustration of the percentage variations which are liable to occur in other parts of the system.

DROP IN CONTINUOUS AND ALTERNATING CIRCUITS.

The word "drop" in continuous-current calculations has a perfectly well-defined meaning. In the case of the five lamps which takes five amperes at 100 volts through a circuit of one-fifth of an ohm, as illustrated in Fig. 5, the drop is (1) the difference between the E.M.F. at the generator and at the lamps, or one volt, which is 1 per cent.; (2) it is the E.M.F. required for sending the current through the line.

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This is equal to the current multiplied by the resistance, and is the E.M.F. which would be required for sending the current through the line if the load be short-circuited; (3) a drop of 1 per cent. means also that the energy lost in the line is 1 per cent. of that delivered by the generator; (4) a loss of 1 per cent. in the line also signifies that the energy delivered is 1 per cent. less than supplied by the generator.

In alternating-current work the same uniformity does not exist; for example, in the experiments with the same five lamps and the same line (1) the generator pressure was 101½ volts, or ½ per cent. higher than that of the lamps; (2) the E.M.F. required for sending a current through a line short-circuited is 10 volts, or 10 per cent.; (3) the energy lost in wires is $C^2 R$, or five watts, which is 1 per cent. of the energy when five lamps are supplied. If four lamps and low-resistance coils are connected to the circuit, the energy delivered is, say, 400 watts, and the loss is 1¼ per cent.; (4) if the coils alone are supplied, and their combined resistance is equal to that of the circuit, or one-fifth of an ohm, then the losses in load and line are equal, and the actual line loss is 50 per cent. The apparent energy at the generator is 550 watts (110 volts and five amperes), and the apparent energy delivered is 500 watts (100 volts and five amperes), so that the apparent line loss is 9 per cent.

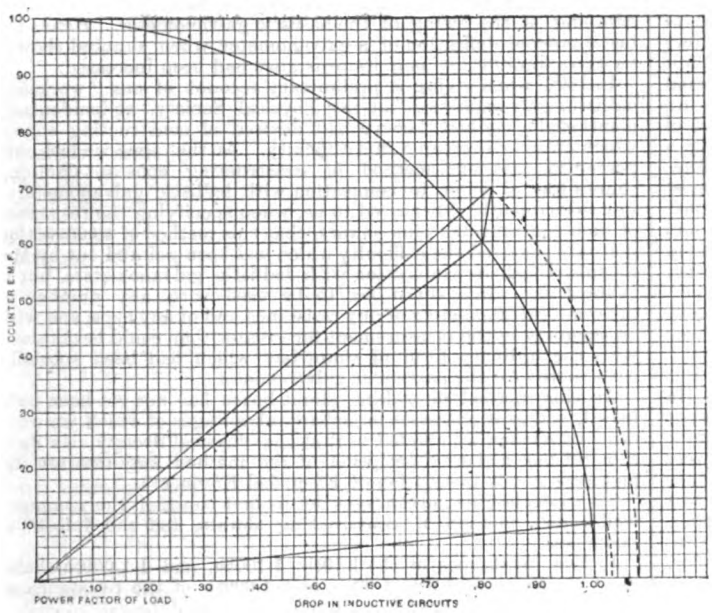

FIG. 10.

It is therefore evident that the several elements commonly referred to as drop or per cent. loss with continuous current are so modified when alternating current is used that it is possible for no two of them to have the same value. Moreover, with alternating current none of these elements may have the same per cent. value as that for continuous current on the same circuit.

LOSS AND REGULATION.

The two vital factors in the line are loss and regulation. The losses are $C^2 R$, and should be expressed in watts or horse-power, or as a per cent. of the energy delivered to the line. The practical point in regulation is the difference in E.M.F. at the generator and at the load. When these two factors are known, it is generally immaterial what E.M.F. might be required for sending current through a short-circuited line. The word "drop" is applied to the difference in E.M.F. between the generator and the load. The regulation is generally expressed in per cent. of generator E.M.F., but in this paper the E.M.F. at the load will be considered 100 per cent., as this is the element to be kept constant while the E.M.F. of the generator is variable, depending upon the load and other elements.

The regulation, or drop in the alternating-current circuit, is dependent largely upon the counter E.M.F. of the line. The factors which practically determine the counter E.M.F. of the line are size of wire, distance between wires, length of circuits, frequency, and current. Mr. A. E. Kennelly has given very complete curves (American Institute of Electrical Engineers, April, 1893) for determining the impedance of pole lines. The impedance factors given may be used for finding the current through a given line which is short-circuited at one end when the E.M.F. and frequency are known. The impedance factor of the line for supplying five lamps, described above, is 10, as the alternating E.M.F. is 10 times the continuous E.M.F. for the same current when the line is short-circuited. The word "drop" is applied in Mr. Kennelly's article to the volts required for overcoming impedance in a circuit, and the impression that this is the same as the drop in continuous-current circuits was not corrected in the paper, nor was this most practical point raised in the discussion. The relation between impedance and loss was, however, demonstrated mathematically in a communication after the meeting. The figures given in connection with the foregoing diagrams show very clearly that a circuit having the same impedance may have a drop between the generator and the load of from 1½ to 10 per cent., depending upon the character of the load. Impedance, therefore, does not determine regulation.

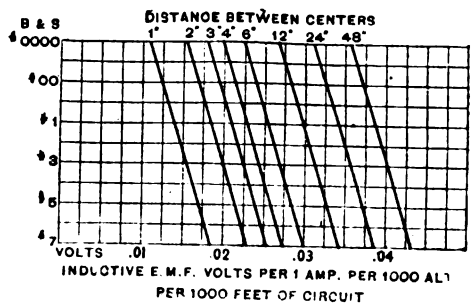
B & S
DISTANCE BETWEEN CENTERS
1" 2" 3" 4" 6" 12" 24" 48"
VOLTS .01 .02 .03 .04
INDUCTIVE E.M.F. VOLTS PER 1 AMP. PER 1000 ALT
PER 1000 FEET OF CIRCUIT

FIG. 11.

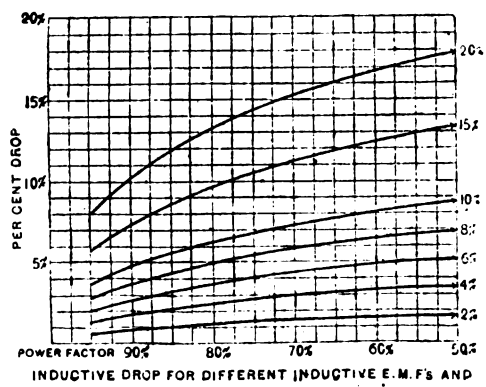

FIG. 12A.

CALCULATION OF DROP IN ALTERNATING CIRCUITS.

The regulation of a circuit is in general determined by two elements: the counter E.M.F. of the circuit and the self-induction of the load. The counter E.M.F. of a line depends upon the size of wire, the distance between wires and increases directly as the length of the circuit, the current and the alternations. The counter E.M.F. of a line has been calculated for a number of cases which are likely to occur in practice, and the results are given in Fig. 11. The drop or difference of potential between generator terminals and the load terminals due to the counter E.M.F. of the line, depends, as has been shown, upon the self-induction of the load. The latter is best expressed by a power factor, or a factor by which the product of the amperes and volts giving the apparent energy must be multiplied to give the true power in watts. The power factor for incandescent lamps is 1·00, or the apparent energy is equal to the true energy. The power factor for converters loaded with incandescent lamps is usually over ·90. The factor for unloaded converters varies from ·50 to ·80, and in open magnetic circuit converters—notably the "hedgehog"—the factor may be as low as ·05. The drop due to self-induction on the line (which, plus the ohmic drop, will give approximately the total drop) corresponding to various power factors of the load is given in Figs. 12A and 12B.

(To be continued.)

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INSTITUTION OF ELECTRICAL ENGINEERS, Mar. 29.

Mr. ALEX. SIEMENS, President, in the chair.

At last night's meeting of the Institution the following candidates were balloted for:

Members.—Proctor, Charles Faraday, the Edison and Swan Company, Limited, Ponder's End, N.

Associates.—Benest, Francis Edward, 30, Cromwell-grove, West Kensington, W.; Davis, Clement Frederick, 75, Gipsy-hill, Upper Norwood, S.E.; Jones, John William, 13, Dornton-road, Balham, S.W.; Wardroper, W. F., 5, Windsor-terrace, Bedford.

Students.—Browning, Walter Buchanan, Faraday House, Charing Cross-road, W.C.; Duddell, William, Kensington Infirmary, Marloes-road, Kensington; Jones, Herbert William, Faraday House, Charing Cross-road, W.C.; Leigh, Frederick Augustus, 6, George-street, Huddersfield, Yorks.; Macfie, James Mathieson, M.A., Faraday House, Charing Cross-road, W.C.; Merritt, Francis Henry, Faraday House, Charing Cross-road, W.C.; Wade, Francis Richard, Gothic House, Beeston, Notts.

After the customary formal business had been transacted, the balance-sheet for 1893 was brought forward, but in view of the discussion on Mr. Mordey's paper and two additional communications to be read during the course of the evening, the **Chairman** proposed that the balance-sheet be taken as read. This was seconded by **Mr. Rawlings** and carried.

The adjourned discussion upon Mr. Mordey's paper was then resumed.

Major-General Webber expressed regret at not having heard the discussion at the previous meeting, but he had read—when they were published—the remarks then made, and had felt greatly struck with the extremely ingenious analogy brought forward by Mr. Mordey to express in physical language the interaction of two alternators running in parallel. He only wished to express one criticism upon the paper, which was to say that he felt sorry Mr. Mordey had not given more details of actual working of alternators in parallel, instead of (or in addition to) his laboratory experiments. That this would have proved of great value and interest, General Webber showed by citing a curious instance of parallel running in the City of London Company's stations, the data upon which Mr. Mordey would be most capable of supplying. In this case, the alternators coupled electrically were in two different stations—one at Bankside and the other at Wool-quay, 2,500 yards distant by cable measurement. The former is a Mordey-Victoria 100-kilowatt machine, driven by a Brush vertical engine at 167 revolutions; the latter a Thomson-Houston 130-kilowatt alternator, driven by a Marshall engine at 170 revolutions. Yet these two machines had been worked for more than 12 months in parallel most successfully.

Captain Sankey gave some additional information respecting the Thames Ditton experiments alluded to by Mr. Mordey. He did not agree with Mr. Raworth as to "hunting" in the governor being the real and only cause of pulsations in the Sunbeam lamps used as resistance; but thought, with Mr. Mordey, that they were caused by efforts to synchronise. He had measured the resistance of the lamps, and found it to be 35 ohms each when cold, this being reduced to 17 ohms with a current of 4·5 amperes passing. He concluded by expressing a wish to see the experiments continued by Mr. Mordey, and made that gentleman a sporting offer. If Mr. Mordey would send a couple of 30-kilowatt alternators down to Thames Ditton, his company would carry out any tests desired, for early publication.

A written communication from Prof. Forbes (who is now in America) was read by his secretary. It consisted almost wholly of a mathematical examination into the parallel working of machines, and did not attempt to deal with many of the questions raised. Prof. Forbes, however, wrote hurriedly, and promised further remarks later on.

Prof. Ayrton gave it as his opinion that the usual methods hitherto employed for synchronising alternators when it is desired to run them in parallel, were cumbersome and useless. He showed by means of a diagram how comparatively easy it is to gauge the exact moment of synchronism by putting the test appliance on the high pressure side; and advocated the use of any ordinary electroscope, say, for instance, one of the common foil-leaf type. This is connected to the two machines—foils to one, container to the other—a very fine connecting wire or conductor being also used to join the two machines direct. As the potential varies from maximum to zero, the period of divergence in the foil leaves becomes slower and slower, until at the moment of synchronism it is *nil*.

Mr. Mordey, in replying to the discussion, said that Mr. Raworth had been under the disadvantage of not having read the paper before the meeting, and that he had therefore probably made a remark which he would not have otherwise done as to the pulsation effect being entirely mechanical. The speaker thought it might have been entirely mechanical, but it might also have been electrical. He had stopped at the pulley of the dynamos, and would leave it to Mr. Raworth to proceed further and settle the matter with Mr. Sankey as to the hunting or otherwise of governors. Mr. Scott had emphasised the question of the steady running of engines in regard to his experience at Deptford. With regard to the spur-wheel analogies, the author was quite aware that all analogies must fail somewhere. He had put forward the analogy of spur wheels for driving and alternate working in a general and popular sense of giving some idea of what took place. He did not quite agree with the conclusion at which Mr. Kapp arrived at on the subject. The question really lay between good and bad regulation, and he agreed with Prof. Thompson that flexible teeth were necessarily weak. The machines necessary for good working in central stations were those which had a constant or nearly constant E.M.F. If they took a machine such as Mr. Kapp had referred to, and excited it for full E.M.F. and no load, and suddenly switched a load on, the volts would go down. He was of the same opinion as Mr. Kapp as to a margin of power, but he did not think that such a margin ought to be obtained by the use of devices which prevented machines from doing work. Prof. Thompson had mentioned parallel working with a common steam supply, without individual governors. The author, who referred to remarks made by himself some time ago on this point, and which supported what the professor had said, observed that the method was sound enough, although engineers might object on the score of steam consumption. Concerning Mr. Sankey's remarks, the hunting could not have been due to a change of load in the experiments mentioned, because there was no load on the machines.

Mr. A. Siemens, in a few remarks, brought the discussion to a close.

The following paper was then read:

A UNIVERSAL SHUNT-BOX FOR GALVANOMETERS.

BY W. E. AYRTON, F.R.S. (PAST-PRESIDENT), AND T. MATHER (ASSOCIATE).

Several years ago Mr. Latimer Clark drew attention to the fact that when shunts were used with a ballistic galvanometer in the comparison of the capacities of condensers, the results were inaccurate if the multiplying power of the shunts were assumed to be the same as those employed with steady currents; shortly afterwards the matter was investigated mathematically by the late Mr. Hockin, and he showed that the inaccuracy was caused by the change which the application of the shunt produced in the damping of the swing of the ballistic galvanometer. Hence the instantaneous deflection of a galvanometer when shunted showed an extra diminution, as if its resistance had been increased.

In 1892, when giving a preliminary account of our "workshop ballistic galvanometers" at the Physical Society, we incidentally mentioned a method that we had devised of constructing shunts which entirely overcame this difficulty. At that time we had only perceived that our method of constructing constant-damping shunts was of value in connection with ballistic galvanometers; but subsequently it occurred to us, when specifying the resistance of such constant-damping shunts, that this method of construction not only removed the difficulty which had been pointed out by Mr. Latimer Clark in connection with ballistic galvanometers, but it enabled the same shunt-box to be used with any number of different galvanometers of any resistance and of any type, and with an accuracy in the measurement far greater than could be obtained with the ordinary form of shunt-box which had been specially constructed for the particular galvanometer.

As this method of making shunt-boxes has not yet been published, and as it possesses important advantages of which we were not aware when we alluded to it at the Physical Society, we have thought that a short description of the method may interest the members of the Institution of Electrical Engineers.

To appreciate its advantages let us first consider the common, well-known method of constructing shunts, and the defects it possesses.

1. The resistances of the 1-10th, 1-100th, and 1-1,000th shunt must have exactly 1-9th, 1-99th, and 1-999th of the resistance of the galvanometer; therefore, if the resistance of the galvanometer be 1,000 ohms, for example, the shunts must have 111·1, 11·11, and 1·111 ohms resistance; hence we must construct the 1-1,000th shunt accurately to the one-thousandth of an ohm if we wish it to be correct to even 1-10th per cent.

2. But the galvanometer is wound with copper wire; we are therefore at once met with the difficulty as to what wire we ought to employ in winding the shunts. If we use German silver, platinoid, manganin, or any substance of low temperature coefficient for the wires of the shunt coils, their resistances may be quite constant, but a rise of 10deg. C. in the temperature of both the shunts and of the galvanometer will make an error of 4 per cent. in the resistance of the former relatively to that of the latter. If, on the other hand, we wind the shunts with copper wire, then, since the shunts are not inside the galvanometer case, it is very difficult to ensure, from the readings of thermometers, that there is not a difference of some 2deg. or 3deg. between the mean temperature of the shunt-box and of the galvanometer, so that the resistances of the shunts may easily be 1 per cent. wrong relatively to that of the galvanometer. In fact, except in the rare case when the galvanometer as well as the shunts are wound with German silver, manganin, or other wire of low temperature coefficient, it is useless spending time making accurate adjustments of the resistances of the shunt coils as ordinarily constructed.

3. Even if the resistances of the shunts be exactly 1-9th, 1-99th, and 1-999th of the galvanometer, they act as if they did not allow 1-10th, 1-100th, and 1-1,000th respectively of the charge in a condenser to pass through the galvanometer when used ballistically.

4. Lastly, for each galvanometer there is needed a separate set of shunts.

All these defects arise from the fact that the method hitherto adopted of varying the current through a galvanometer while the current in the main circuit remained the same, has consisted in varying the resistance of the shunt to the galvanometer. If, however, we leave the shunt to the galvanometer untouched, and instead vary the current through the galvanometer by varying the point of attachment of the main leads, we remove all these difficulties at once.

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A shunt-box constructed in this latter way is seen in Fig. 1. The terminals A and B of the shunt-box are permanently connected respectively with the terminals of the galvanometer, G, while the terminals B and C of the box are connected with the two main wires which lead the current up to, and away from, the galvanometer and shunt. The ends of a coil of any resistance, r ohms, are permanently connected as shown, and at points in this coil corresponding with $\frac{r}{10}$, $\frac{r}{100}$, $\frac{r}{1,000}$ ohms permanent connections are made with the various blocks of the shunt-box as illustrated.

Then, whatever be the resistance of this coil, r, compared with the resistance of the galvanometer, g (either or both of which may therefore be unknown), it is easy to show that if G amperes be the current flowing round the galvanometer when a plug is placed into the hole marked d, it will be $\frac{G}{10}$, $\frac{G}{100}$, and $\frac{G}{1,000}$ amperes respectively when the plug is put instead into the holes marked c, b, a respectively, provided that the current in the main circuit remains constant—the condition which is, of course, assumed to be true in the ordinary use of shunts. Or, if a definite quantity of electricity flow into or out of a condenser in the main circuit, and Q coulombs be the quantity of electricity that flows round the galvanometer when the plug is in the hole marked d, $\frac{Q}{10}$, $\frac{Q}{100}$, and $\frac{Q}{1,000}$ coulombs will be the quantities that flow round the galvanometer when the plug is put into the holes c, b, and a respectively, and the deflections will correspond with these quantities.

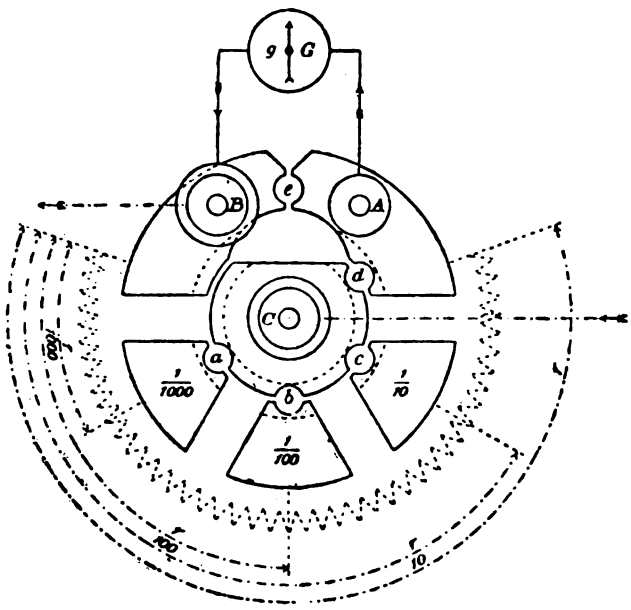

FIG. 1.

For let the constant current in the main circuit be called A: then when the plug is in hole d, the galvanometer current equals

$$\frac{r}{r+g}\text{ A, say G;}$$

when plug is in hole c, the galvanometer current equals

$$\frac{\frac{r}{10}}{\frac{r}{10}+\left(\frac{9}{10}r+g\right)}\text{ A, or }\frac{G}{10};$$

when plug is in hole b, the galvanometer current equals

$$\frac{\frac{r}{100}}{\frac{r}{100}+\left(\frac{99}{100}r+g\right)}\text{ A, or }\frac{G}{100};$$

when plug is in hole a, the galvanometer current equals

$$\frac{\frac{r}{1,000}}{\frac{r}{1,000}+\left(\frac{999}{1,000}r+g\right)}\text{ A, or }\frac{G}{1,000}.$$

Similarly, if K be the number of coulombs flowing into, or out of, a condenser in the main circuit, and p K, or Q, be the number of coulombs that flow round the galvanometer when the plug is put into the hole marked d, it may be proved that, since the resistance of the galvanometer plus that of the shunt is constant, and therefore the damping is constant, the quantities of electricity that will flow round the galvanometer when the plug is put instead into the holes marked c, b, and a respectively, are $\frac{Q}{10}$, $\frac{Q}{100}$, $\frac{Q}{1,000}$ coulombs.

Hence, the galvanometer may be wound with copper or with any other wire; a single set of shunts may be made of manganin wire, and be accurately sub-divided into exact numbers of ohms, fractions of an ohm being unnecessary with our system; the galvanometer may have any resistance and be at any temperature, provided it is constant while a set of tests is being made—then the sub-division of a steady current or the sub-division of an instantaneous rush of electricity into parts having the ratios of 1, $\frac{1}{10}$, $\frac{1}{100}$, $\frac{1}{1,000}$, is effected with great accuracy.

Stock shunt-boxes, ready wound for use with any galvanometer, in the measurement of steady currents or of instantaneous rushes of electricity are exhibited on the table.

The arrangement of shunt-box illustrated in Fig. 1 may be regarded as possessing one defect—viz., that the whole current flowing in the mains cannot be sent round the galvanometer without disconnecting the main wire from the terminal C, and connecting it instead with the terminal A. To save the trouble of having to do this, and to enable every combination to be made by simply shifting the plugs, we sometimes construct the blocks of the shunt-box as seen in Fig. 2. When one plug is placed and left in the hole marked h, and a second plug is placed in one or other of the holes marked d, c, b, or a, we obtain exactly the results already described in connection with the box seen in Fig. 1. Placing, however, one plug only in the hole marked f, the entire current flowing in the mains circulates round the galvanometer. If a plug be placed in the hole f, and another in the hole j, the galvanometer is short-circuited—a result obtained by placing the two plugs in the holes marked d and e in Fig. 1. The arrangement shown in Fig. 2 has the further advantage that it is possible, by putting a single plug into the hole marked j, to disconnect one terminal of the galvanometer from the circuit without breaking the circuit. This method of connecting is convenient to employ when taking the zero with a very sensitive galvanometer, for in that case it may happen that, although the galvanometer is apparently short-circuited through a very low

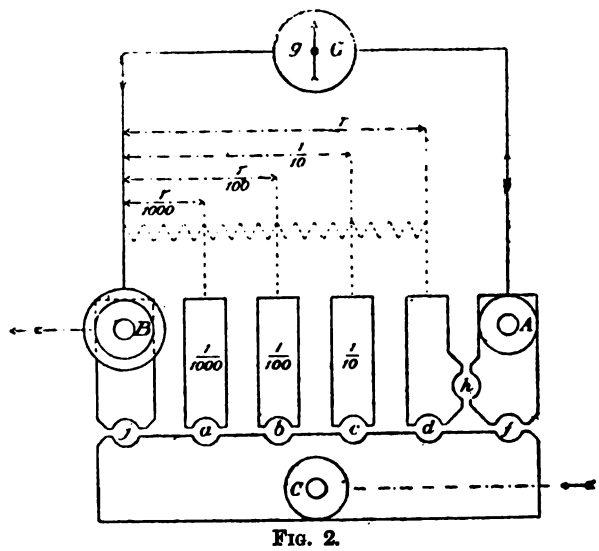

FIG. 2.

resistance, enough of the main current, although but an extremely small fraction, passes round the galvanometer to produce a small deflection.

When, however, r is more than about 10 times as great as g, the simpler form of shunt-box illustrated in Fig. 1 is sufficient for ordinary purposes; for, although by merely shifting the plug with this type of box, it is impossible to send a greater current round the galvanometer than $\frac{r}{r+g}$ A amperes, where A is the current in the mains, this value of G, being more than $\frac{10}{11}$ A, is sufficiently near A for ordinary purposes.

Of course, whatever be the value of r, whether large or small compared with that of g, the current that flows round the galvanometer when the plug is put into the poles marked c, b, and a respectively, is exactly 1-10th, 1-100th, and 1-1,000th of its value when put into the hole marked d. The only advantage that is gained by making r large compared with g is that $\frac{r}{r+g}$ A, or G, the unit current, becomes then practically equal to A.

The method of using shunts above described has, then, the advantage that it enables the same shunt-box to bo used with any galvanometer of any resistance, whether ballistic or not; but it does more than that, for a consideration of our method of varying the point of attachment of one of the mains, instead of varying the resistance of the shunt itself, shows that any ordinary resistance-box can be employed as a shunt with any galvanometer, and the fractions of the current that pass round the galvanometer and through the shunt respectively can be read off at once, without any calculation and without a knowledge of the resistance of the galvanometer, to a far higher degree of accuracy than is possible with a set of shunts specially constructed for the particular galvanometer in the ordinary way.

By employing this device we also find that great simplification and cheapening of cost is effected in the employment of a d'Arsonval galvanometer with shunts of platinoid or manganin sheet for the measurement of electric currents over a wide range.

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THE
ELECTRICAL ENGINEER.

Published every Friday.
Price Threepence; Post Free, Threepence Halfpenny.
Editorial and Publishing Offices:
139-140, SALISBURY COURT, FLEET STREET,
LONDON, E.C.

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LONDON REFUSE.

After the developments—or perhaps we should say convulsions—which were manifested not so very long ago in the Elmore companies and kindred financial circles, we almost began to hope that the field was cleared of those who pull the wires and make the puppets act in such wise as to draw liberal contributions from open-mouthed and empty-headed onlookers.

Doubtless the wily promoter of companies could well afford to "lie low" for a while, instead of prevaricating on high and in public; but for some reason—either because a slight improvement in the money market shows that there is more readiness to invest, or else because lack of funds makes it necessary to concoct some fresh scheme—still another sample of the bogus company is trotted out under the guise of "electrical inventions," as though that blessed word "electricity" were able always to prove an admirable and infallible nostrum for the financial *prestidigitateur*.

Under any other title the scheme of the London Refuse Steam Generator and Electrical Power Corporation, Limited, would prove no whit better investment for widows and orphans, whilst as it is, such an appellation is almost enough in itself to condemn the enterprise unheard. There may be, and doubtless are, exceptions to the rule, but in at least nine cases out of ten the amount of sinfulness in the promotion of a new company varies in strictly direct ratio to the length of the company's title. When one comes to examine closely into the stated objects, conditions, and prospects, the preliminary adverse judgment thus formed is, to put it mildly, confirmed through and through, finally, once and for ever. We have not hitherto commented in any way upon the extraordinary prospectus, and statements therein contained, with which the guileless and silly-headed public has been favoured within the last few weeks; the details of the scheme, the lack of strong support from men of any real standing, the absurd pretensions brought forward, were all so obvious that we expected no other results than a pleasant little time for those engaged in promoting the enterprise so long as the bubbles could be blown, and a nice little bill for someone to pay after the funeral—preferably, we should hope, the wire-puller at the back of the whole business.

If, however, there be the least chance of any disposition on the part of the public to invest a few pounds, or even a few pence, in helping to pay £400,000 in cash *or shares* to those interested in developing the Livet patents, then any criticisms we may pass upon the scheme from a technical and common-sense point of view will perhaps serve a useful purpose in restraining such a waste of good money. The Livet patents may be sound, and capable of maintaining their own in a court of law: we do not deny it, though if they occupy that enviable position they are, in a sense, unique. In such a case they would have an undoubted value—how great a value depends entirely upon the extent to which they hold a monopoly of appliances suitable for the efficient and economical destruction of house and other town

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refuse. We believe such monopoly to be absolutely and wholly non-existent; and, in addition to this, we are confident that not only have better contrivances been a matter of history for some years, but hardly a month passes by without some improvement in methods or machinery. At the present time there are as many "systems" of efficient dust destructors as fingers on the hands, yet none of them can be said to have come into extensive use, and certainly have never been priced at figures fabulous or otherwise.

We have neither space nor inclination to follow out here all the mis-statements and misprints of the prospectus. That has already been done to advantage by a well-informed section of the daily press. We can, however, express ourselves strongly upon the fact that not a single engineer of repute will be found to say a word in justification of the claims made in the prospectus. Mr. Edwin E. Glaskin, M.A., S.C.E. (whatever these letters may mean), may be a capable engineer, but he is unknown when compared with Bramwell or Kennedy, and, speaking without any disparagement, we cannot accept his assertions as to steam trials confessedly of an imperfect nature. Chance statements made by engineers and technical papers appear to be dragged in as expressing approval of the scheme when really dealing with the matter in a general fashion: whilst the figures as to cost of plant, working expenses, probable profits, etc., are presented in the usual attractive and glittering form. It may seem quite correct and proper for an ignorant investor to see reports dealing with temperatures of feed-water and flues, pounds of water evaporated, and so forth (why not also give the state of the stoker's pulse, or the humidity of surrounding atmosphere?): but if this sort of thing is meant to appeal to the initiated, complaint must not be made if the latter say that the title of the company might with greater fairness be "London Refuse, Unlimited."

The sooner it is tumbled into one of its own destructors and turned into "steam of 250,000 c.p." the better for the community and world at large. At present one can only say that a possibly useful appliance in the shape of a boiler and furnace having somewhat novel features has been made the means of attempting to draw huge sums from the public in return for prospects of an extremely doubtful nature.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

ELECTRIC TRACTION ON ROADS.

SIR,—In the *Electrical Engineer* of January 25, 1889, you treated of the "red flag clause," and stated that the question was brought forward at the last session of Parliament, 1888, and that the Act was interpreted as only applying to fuel-consuming vehicles; special mention was made of electrically-propelled carriages.

Again, the Inland Revenue department issue a notice to the effect that licenses must be obtained, etc.: "Carriages drawn by two or more horses or mules, or to be drawn or propelled by mechanical power."

I am much interested in the subject, and will give you details of trial of carriage shortly.

I have not seen letter to the *Times* referred to; naturally, I look at electrical papers for electrical subjects. If I cannot run my carriage in England it must go to Paris or Madrid, where every encouragement is being thrown out and no legal obstacles exist.—Yours, etc., C. R. G.

Birmingham, March 26, 1894.

[Our correspondent will doubtless be interested in the competition on this subject referred to in our "Note" columns.—ED. *E. E.*]

THE BRUSSELS MUNICIPAL ELECTRIC LIGHT STATION.

THE INCEPTION OF THE STATION.

The Municipal Council of Brussels have for several years had under consideration the question of lighting the town by electricity. It was for some time undecided whether to introduce a municipal supply or to grant a concession to a company, but eventually it was resolved to adopt the former course. As a result of this decision, a general specification was prepared in April, 1891, and tenders were invited from different quarters for a complete scheme, comprising both public and private illumination. The system to be introduced was not specified, but full details of the proposed method were required, together with particulars of the estimated working expenses. At the same time it was notified that the contractor selected to carry out the enterprise would be required to undertake the working of the station for two years, and would be liable to heavy fines in the event of the actual working expenses during that period exceeding the estimates. The schemes submitted included both alternating and direct current systems, and the municipality selected a three-wire low-pressure distribution method worked in conjunction with accumulators. On December 5, 1892, the India Rubber, Gutta Percha, and Telegraph Works Company, of Silvertown, and Persan-Beaumont, represented in Belgium by Mr. Boty, were entrusted with the execution of the contract, on the understanding that, or far as possible, all machinery, etc., should be constructed in Belgium, and that the whole of the contract should be completed in eight months after the site for the station had been placed at their disposal.

The site selected for the central station was that occupied by the old church of St. Catherine, Rue Melsens, in the lower part of the town, adjoining the main boulevard, and this ground, with the church and buildings upon it, was handed over to the company on February 13, 1893. The work of demolition was commenced on the same day, and this, together with the excavating work for foundations—which necessitated the removal of about 7,000 cube yards of earth, and the clearing away of the massive foundations of the old church—occupied a period of about 10 weeks. Eventually, in the middle of May, the construction of the new buildings was commenced by the contractor, M. La Barre, acting under the instructions of M. Devreux, the architect, and of the company's resident engineer, Mr. Stuart A. Russell.

THE STATION BUILDINGS.

The buildings include a boiler and machine room on the ground floor, and on the first floor a battery-room, repairing shop, and stores over the machine-room, whilst the coal-store, water purifiers and tanks are placed over the boiler-room. The chimney, which is 190ft. high and 8ft. 4in. internal diameter at the top, occupies an angle formed by the boiler and machine rooms, and is built of radial bricks and carried on a brick and concrete foundation 15ft. deep. The offices necessary for the administration and the testing-rooms are arranged in the same block of buildings, but occupying a strip of land separating the station proper from the Rue Melsens. The coal-store, which has a capacity of 200 tons, is on the first floor, and an electric lift has been constructed to convey the fuel to it. It is proposed to construct a small tramway to the Willebroeck Canal to facilitate the discharge of fuel brought by water. From the coal-store the fuel is conveyed by suitable shoots to the stoking space—these

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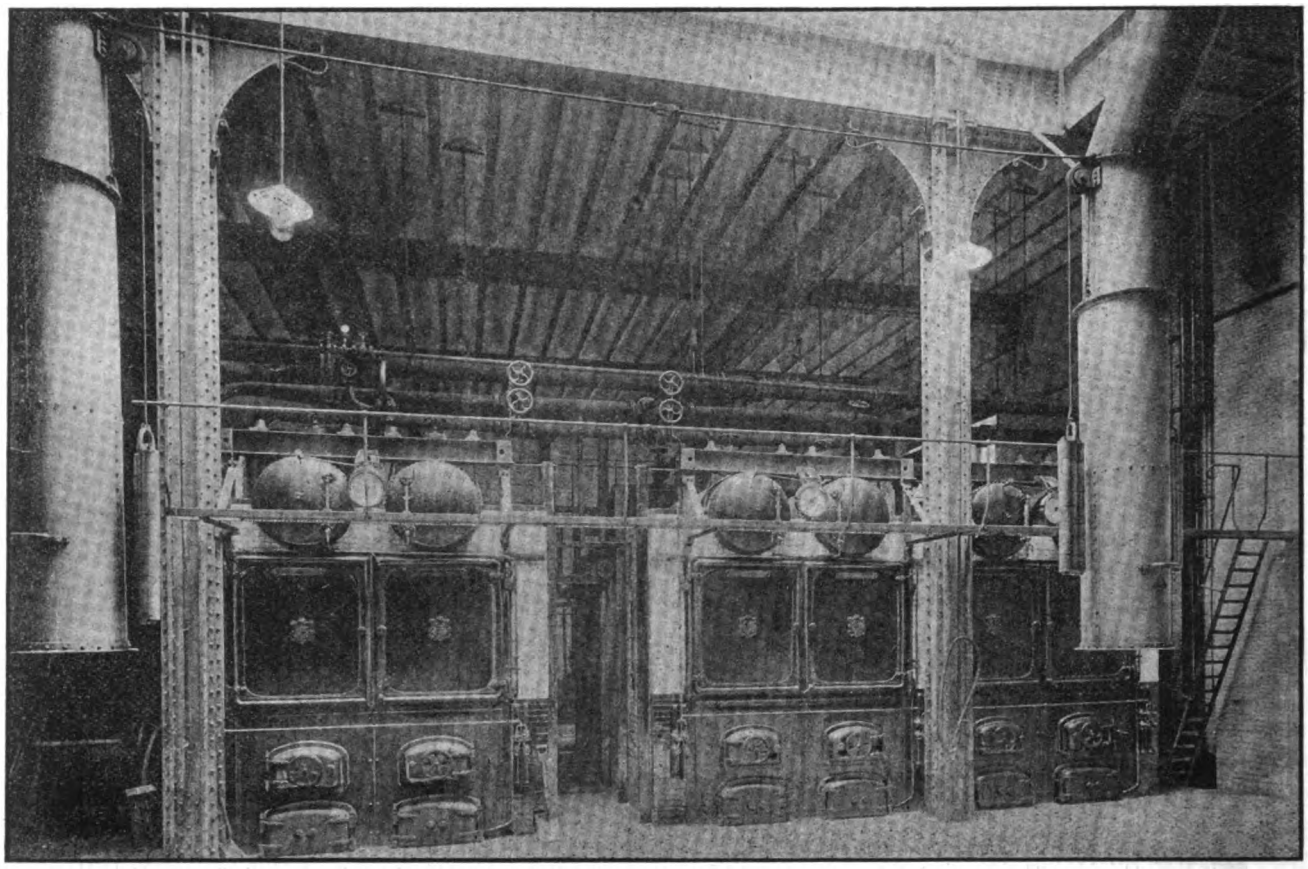
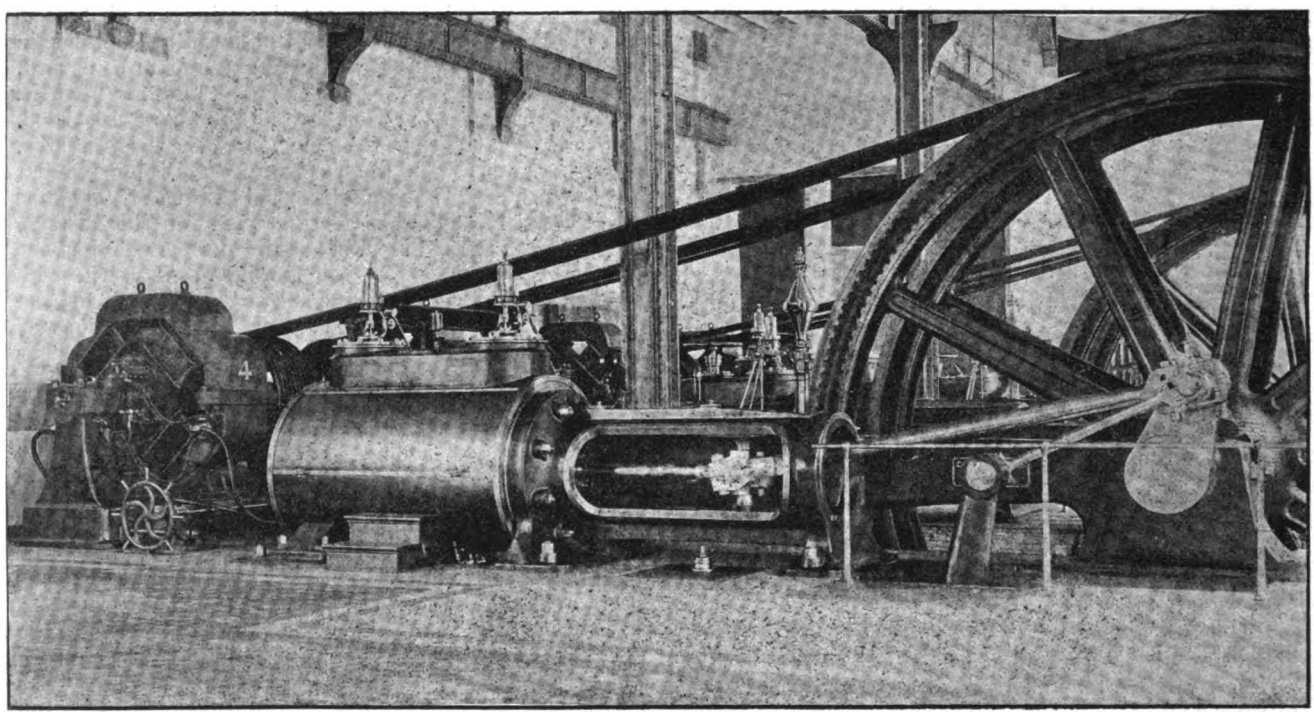
shoots being telescopic, so that they may be lowered to avoid the making of dust when coal is being discharged, and raised out of the way at other times. The water supply, both for condensation and feed, is obtained from the Willebroeck Canal, which is distant about 350 yards. Two 18in. pipes have been laid down with a slight fall from the canal to a small reservoir under the machine-room, to which are brought the suction pipes of the condenser pumps. A certain quantity of the condensing water, according to requirements, is pumped up to the water-purifier, from which it is discharged into the main tanks. The water-purifier, which is of the Dervaux type, is capable of dealing with about 2,500 gallons of water per hour, and the capacity of the main tanks—two in number—is about 22,500 gallons.

The station, when complete, will contain plant of 3,000 i.h.p.; the unit adopted being a 500-h.p. engine driving two 250-h.p. dynamos. Provision has been made for laying down six such units, one being a reserve; but as the specification of the municipality stipulated that the machinery should be capable of working at 25 per cent. in excess of its normal full load, the ultimate maximum working capacity of the station may be taken as 3,000 h.p., not including reserve.



Brussels Central Station—The Boiler House.



Brussels Central Station—View of Engines and Dynamos.

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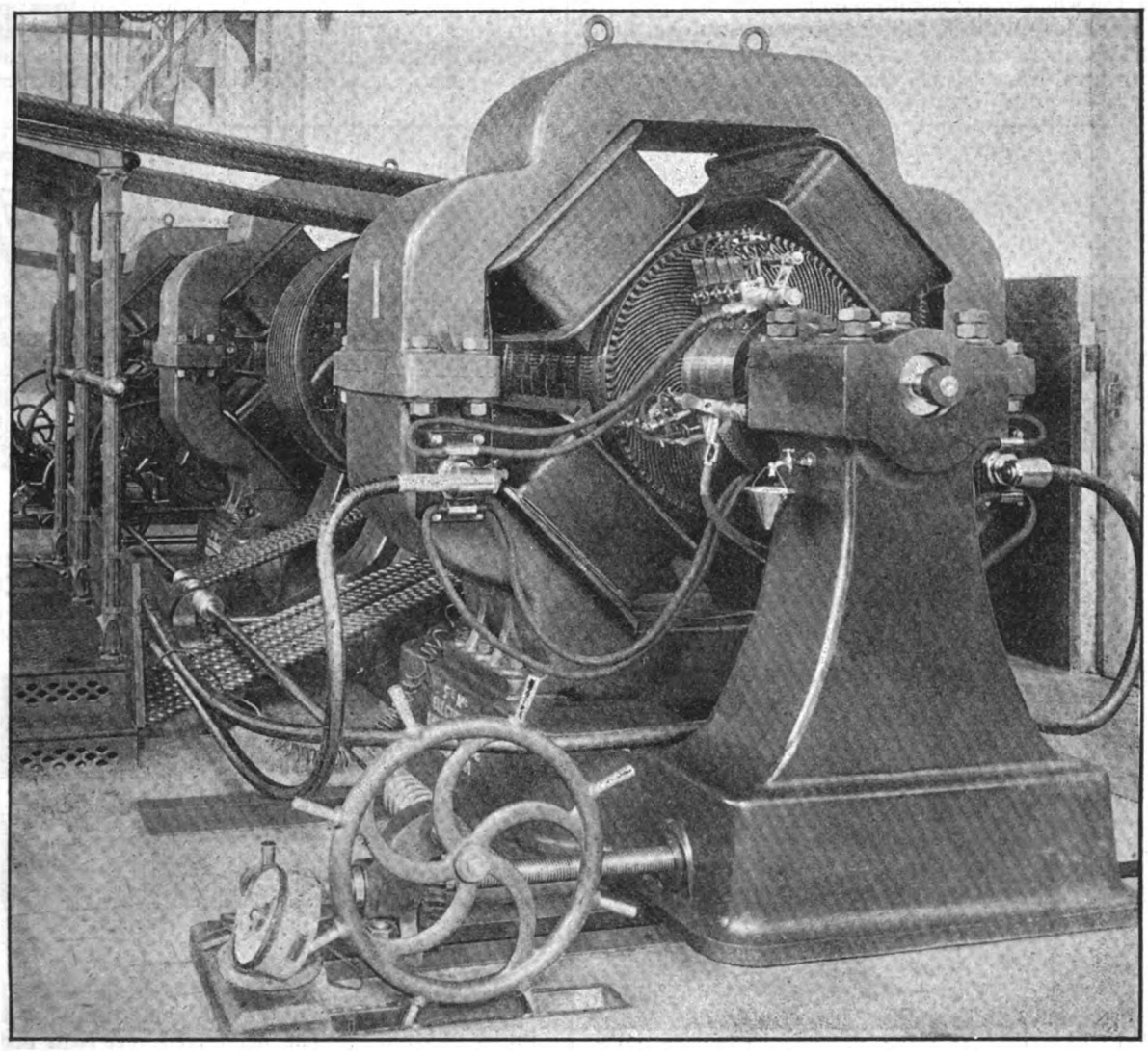
The Boiler-house.

The present plant consists of three Babcock and Wilcox boilers, constructed by Brouhon, of Liège; each has a heating surface of 2,440 square feet, and is capable of evaporating 7,500lb. of water per hour—with a good quality of Belgian coal. The boilers are of the usual type, working at 135lb. pressure, but having a specially large grate surface (56 square feet) to allow of coke being used for firing instead of coal. The boilers are fed by a Worthington pump, a second being held in reserve. Each pump is capable of supplying to the boilers 2,600 gallons of water per hour, the water being drawn from a small cistern at the back of the boilers, to which the water descends from the main tanks, the supply being regulated by a ballcock. This cistern can also be supplied with water from the town mains, in case of an accident preventing the use of the supply from the canal. The feed-water passes from the pumps, through a Green's economiser, of which two have been provided, each of 2,160 square feet heating surface, and thence to the boilers. All the feed piping is doubled, and is so arranged that any boiler can be fed by either pump, the feed-water passing through the economiser, or, in case of repairs to this apparatus, directly to the boiler. All the steam-piping is also double, two main pipes running across the tops of the boilers being carried through into the machine-room, and running in a subway the whole length of it. Each boiler is connected to each of the two main pipes by a branch provided with a stop-valve, and a branch is taken from each main pipe to each engine.

The Engine and Dynamo Room.

The machine-room, which is 120ft. by 52ft. and 28ft. high, contains the engines, dynamos, and switchboard, and is fitted with an overhead traveller running its whole length, and capable of lifting 15 tons. To fulfil the stringent conditions as to the absence of vibration, a block of concrete, about 6ft. thick, has been laid as a foundation, which extends over the whole surface of the engine-room, but it is entirely independent of and isolated from the foundations of the building. On this block the brickwork foundations—also separated from the walls of the building—for the engines and dynamos have been built. The engines, two in number, are of the Sulzer horizontal, side-by-side, compound condensing type, having adjustable cut-off, supplied by Carel Frères, of Ghent.

The low-pressure cylinders are 40in. diameter, and the high-pressure cylinders 26in. in diameter, the length of stroke is 4ft., and the speed is capable of variation between 62 and 75 revolutions per minute, the higher speed being necessary for the charging of the accumulators. Each engine is fitted with two nine-groove fly driving-wheels 20ft. in diameter, and weighing 20 tons. The most economical load for each machine is 400 h.p., so that for a range of 250 h.p. to 625 h.p. the consumption of steam per brake horse-power is small, and a good efficiency should be assured on the average working load throughout the year. For engines of a similar type constructed by the same firm, tests carried out by the association for the supervision of boilers give the following results: On an engine constructed for a normal output of 500 h.p. at 60 revolutions, when working at 138 h.p. with 5·7 atmospheres pressure (85lb.), the steam consumption on a test of eight hours was rather less than 13lb. steam per indicated horse-power hour. With a similar type of engine of 400 h.p. size, working at 5·8 atmospheres (87lb.), and indicating 250 h.p., the steam consumption was 13·1lb. The same engine, tested 5½ years later, gave a consumption of rather less than 14lb., working at 6·9 atmospheres (103½lb.), and indicating 330 h.p.



Brussels Central Station—End View of Line of Dynamos.

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The engines are erected side by side with the cylinders at right angles to the length of the hall, and each engine drives two dynamos by means of 18 1⅝in. ropes. The dynamos are of the four-pole type, shunt wound, with drum armature, running at 300 to 360 revolutions per minute, with an output of 145 kilowatts as the normal full load, but capable of working up to 180 kilowatts for a continuous run of 12 hours, without over-heating or sparking at the brushes. These dynamos are carried on slide rails, to allow of the tightening of the rope-drive as required, and are fitted with self-oiling bearings. They have been constructed, as was the switchboard, by the Société Electricité et Hydraulique, to designs and plans supplied by the Silvertown Company.

The Dynamo and Switchboard Connections.

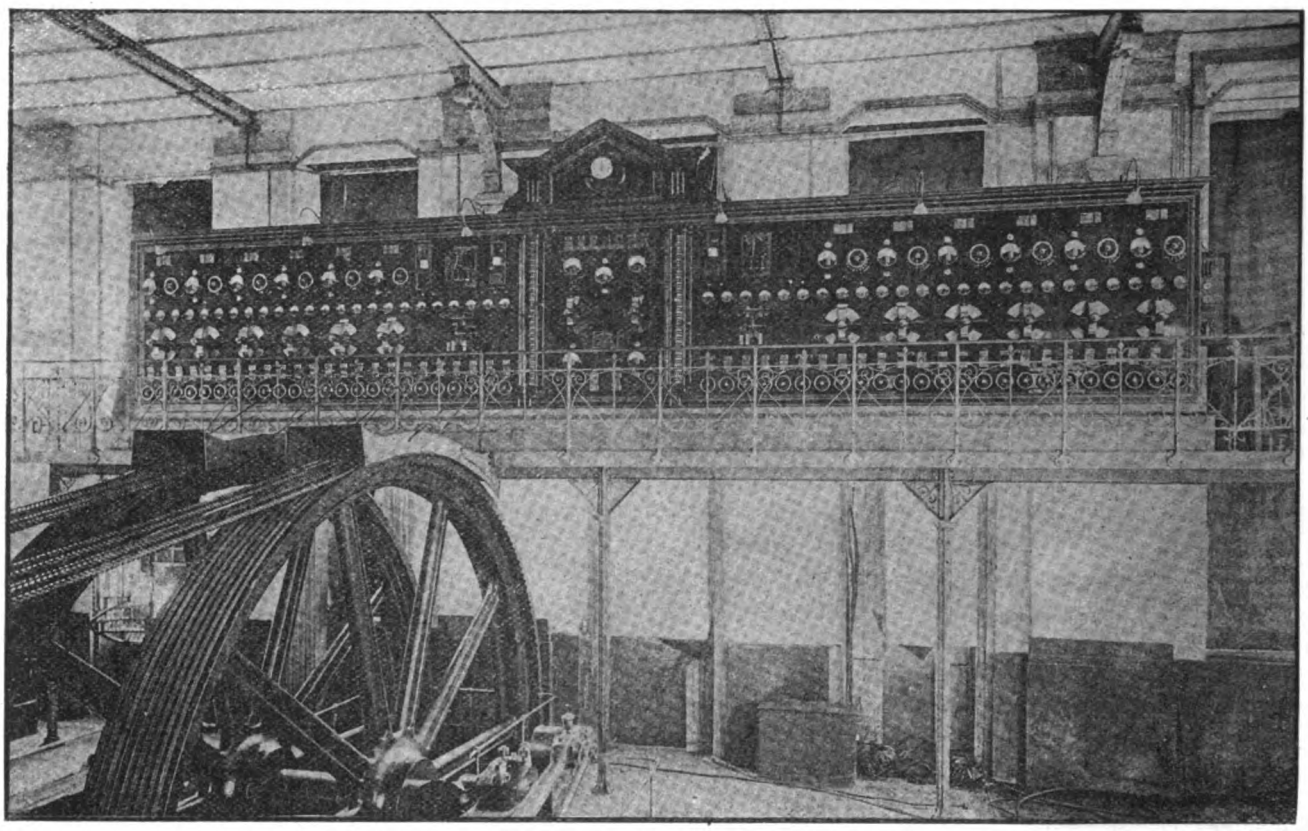
The switchboard is fitted for six pairs of dynamos, a battery of accumulators, and 24 feeders, and is formed of a series of black marble panels carried in a wrought-iron frame, the whole being mounted on a gallery fixed against one of the long walls of the engine-room, at a height of about 14ft. above the floor. Thus the attendants have an uninterrupted view of all the machines. The general scheme of connection of the switchboard is as follows, each set of connections being the same for each pair of dynamos.

The positive pole of No. 1 dynamo is connected permanently to the negative pole of dynamo No. 2, and both are connected through a fusible cut-out to the neutral omnibus bar of the switchboard. The negative pole of No. 1 dynamo is connected through a fusible cut-out and an ampere-meter to the fixed terminal of a two-way switch, by means of which the circuit can be made either on to the charging circuit of the accumulators or on to the negative omnibus bar. The positive pole of No. 2 dynamo is connected in the same way to the accumulators or positive omnibus bar.

The exciting circuit of the dynamo is arranged as follows: the positive terminal of the shunt on dynamo No. 1 and the negative of No. 2 dynamo are permanently connected to the corresponding main dynamo terminals, and therefore to the neutral omnibus bar on the switchboard. The negative terminal of the shunt on dynamo No. 1 is connected to a switch fixed on the dynamo, through which the circuit is connected to the negative omnibus bar, an adjustable resistance fixed on the switchboard being interposed to permit of variation in the exciting current. The positive terminal of No. 2 dynamo is connected in the same way to the positive omnibus bar on the switchboard. The shunt circuit switches on the dynamos are specially arranged to close the circuit of the shunt on that of an auxiliary resistance at the moment of rupture, to diminish the sparking and strains on the insulation caused by the E.M.F. due to self-induction on breaking the circuit.

Distribution.

For the main feeder circuits, of which there are 24, each positive feeder is connected through a separate adjustable main resistance and fusible cut-out with the positive omnibus bar, the negative feeder being connected in the same way to the negative omnibus bar, the intermediate feeder being connected directly to the intermediate omnibus bar. To each distributing centre is led a three-core potential cable, conductor $^{7}/_{20}$ L.S.G., connected at one end to the three main cables in the distributing-box at the centre, and at the other end to a pair of voltmeters mounted on the switchboard, to indicate the pressure between the positive feeder and the intermediate, as also between the negative feeder and the intermediate.



Brussels Central Station—General View of Switchboard.

The pressure is kept constant on each side of the intermediate cable by varying the absorbing resistance in the main feeder circuits. The main resistance is of platinoid strip and fitted with contacts, to allow of separate adjustments of half volt at full load.

The centre panels of the switchboard carry the registering ammeters, automatic switches, battery regulators, etc., for connecting up the accumulators. Twenty-six cells at the positive end of the battery, and the same number at the negative end, are connected to regulator switches; and the middle terminal of the battery is connected to the neutral omnibus bar, thus allowing of the number of accumulators in use to be varied as required. The discharge side of each regulator is connected through a registering ammeter, a switch and fusible cut-out to the corresponding omnibus bar, and the charge side of each regulator through a registering ammeter and automatic switch to the battery contact of the two-way dynamo switches.

The accumulators are of the Julien type, and comprise 140 cells, forming a double battery of 70 cells. Each cell is capable of giving a normal discharge of 350 amperes

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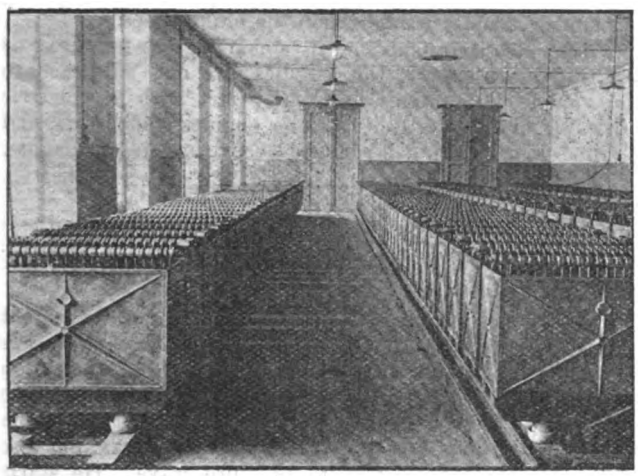
for 10 hours, and in case of necessity the discharge may for a short time be carried up to 1,400 amperes without undue deterioration. The cases are of an alloy of lead and antimony. The plates are widely separated, and ample space is left at the bottom for all material that may become detached during work. The total weight of the battery is 80 tons.

The Mains.

For the three-wire distribution, each cable is drawn into a separate cast-iron pipe, with the exception of the potential cable, which is drawn into the same pipe as the intermediate cable. All the cables are continuously insulated, the joints being vulcanised. The conductors are of high conductivity copper—100 per cent. Matthiessen's standard—tinned and insulated pure, then vulcanising indiarubber, taped over all, and the whole vulcanised together, strongly braided flax, and covered with preservative compound. The insulation resistance is 1,500 megohms per mile, tested in water at 60deg. F. after 24 hours' immersion and one minute's electrification.

The whole plant was completed and in working order by October 11, or two days before the date fixed by the contract. The speed at which the work was executed may be further estimated from the fact that, although the definite plan for the system of mains and their laying was only approved by the middle of June, more than 55 miles of pipe were laid, and 26 miles of cable, including a large quantity of 1in. and



Brussels Central Station.—The Battery Room.

1¼in. section conductor, was manufactured in England, delivered, and laid before the opening of the station. The work of canalisation was carried out by Mr. Daubeny, assistant engineer to Mr. Russell. The plant and canalisation have been examined and approved by the experts appointed for that purpose. The station was formally inaugurated by the Bourgmestre and Echevins of Brussels on November 9, since which time it has been giving a continuous night and day service to the complete satisfaction of the town.

Notwithstanding the rapidity with which the work was carried out, the solid construction of the buildings, and the simple but complete establishment of the station, show that durability and efficiency are in no way sacrificed to speed in completion, and at the lunch following the inauguration the India Rubber Company received the hearty congratulations of its guests on the success of the undertaking, and the skill and energy displayed by the company's representatives—Messrs. Gray, Boty, and Russell. It is to be hoped that this, the first central station erected by an English firm in Belgium, may be shortly followed by others with equal success.

The Use of Indiarubber-Insulated Cables.

It is interesting to note that this is the first large central station worked on the low-tension system in which the method of distribution has been carried out with india-rubber-insulated cables. It has hitherto been held that the price of such cables was prohibitory—at least for the larger sizes. This question of prime cost is too often considered at the expense of efficiency, and it certainly appears reasonable that any town having facilities for the borrowing of money at a low rate of interest should not decide only on prime cost, but consider closely the important point of cost of maintenance, since in many cases, if this cost were capitalised, it would be found more economical to incur a heavier initial cost than to adopt any special system merely on account of low prime cost. Although, as we have said, this is the first large low-tension station that has adopted such cables throughout, yet we are glad to see that the company who have carried out the work have in the last year supplied some considerable quantities of these cables to towns where a low-tension system has been adopted—for instance, at Manchester, Glasgow, Dundee, and Paris (where this type is now being largely adopted). For the high-tension system, where hitherto it has been considered that insulation is of more importance than for low tension, we understand this company has supplied, in whole or in part, the cables for the following towns, where the results obtained have been invariably satisfactory: London (over 300 miles in use), Paris, Madrid, Brussels, Dublin, Newcastle-on-Tyne, Leeds, Huddersfield, Blackpool, Eastbourne, Hastings, Brighton, Bournemouth, Scarborough, Chelmsford, Burton-on-Trent, Cardiff, Oxford, Cambridge, Woking, Melbourne, Buenos Ayres, Hong-Kong, Tours, Barcelona, Havre, Rouen, and Montpellier.

Initial Cost is not the First Consideration.

These results go far to prove the fallacy of the idea advanced in the earlier days of electric lighting, when it was held by many electrical engineers that no insulation would be found to be durable underground when employed for high-tension alternating current. The reason of the repeated failures was no doubt the too close consideration of prime cost without regard to maintenance; and it remains now to be proved whether the same considerations do not apply to low-tension distributions, and whether the experiments, extending over a number of years, which were carried out by the electricians interested in telegraphy are to be still ignored, on the supposition that the application of electric lighting is on a totally different footing in all respects from underground telegraphy, and that new insulators have now been rediscovered which can adequately replace the lasting, but no doubt costly, vulcanised indiarubber. A sign of the times is that many of the leading cable-manufacturing companies have within the last few years turned their special attention to the manufacture of this type of cable, and if by so doing these cables can be further cheapened without detriment to their efficiency and durability, a great advance will have been made towards the wider adoption of a reliable insulator.

HOW SHALL WE OPERATE AN ELECTRIC RAILWAY EXTENDING ONE HUNDRED MILES FROM THE POWER STATION? *

In a paper presented at the last meeting of the American Institute of Electrical Engineers, Mr. H. Ward Leonard considered the question of operating an electric railway 100 miles from the power station. The assumption was made that there exists a very economical source of power, possibly a water power, so situated that the length of railway to be operated in either direction is 100 miles.

The following features seem desirable, if not essential, in such a railway: (1) a single trolley contact shall be used for supplying current to the locomotive; (2) the E.M.F. upon the trolley shall not exceed 500 volts; (3) there shall be no apparatus in motion and requiring attention between the power station and the locomotive; (4) no commutator, rheostat, or controlling device on the locomotive shall be subjected to a higher E.M.F. than 250 volts, and there shall be no sparking on any of the apparatus under any normal conditions; (5) the entire control of the locomotive in either direction shall be effected by the movement of one lever; (6) the load shall be started from dead rest by an amount of energy taken from the source of supply which shall not exceed one-quarter of the energy required to

* From the *Electrical World*.

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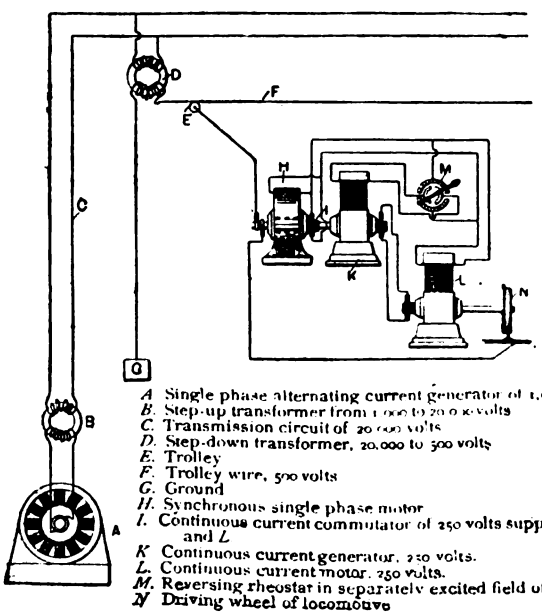
operate at full speed on the level; (7) the retardation of the load in coming down grades, and in stopping, shall be effected by converting the motors into generators, which shall feed back current to the line, and thereby assist the power station in operating other locomotives; (8) the motors must be reversible when operating at full speed without damage to the motors or other apparatus; (9) the efficiency of the system from power on the generator shaft to the drawbar pull of the locomotive shall be at least 50 per cent.; (10) the locomotive shall produce at least 500 h.p. when operating at a speed of 80 miles per hour.

For such great distances, in order to operate with a loss in conductors of 20 per cent., the initial E.M.F. must be 20,000 volts, in order to make the cost of copper 20dol. per kilowatt, which is about the best figure for cost of copper under the conditions. The alternating current must evidently be used, and as there is but one trolley contact, it must be single phased.

The system proposed, which is diagrammatically shown in the accompanying illustration, is briefly as follows: Starting with standard 1,000-volt, single-phased alternators in the power station, the potential is raised to 20,000 volts by step-up transformers. At suitable points, say every two miles, the potential is transformed down to 500 volts. Now, with this current, a synchronous alternating motor can be operated, but cannot be regulated in speed, reversed,



A. Single phase alternating current generator of 1,000 volts
B. Step-up transformer from 1,000 to 20,000 volts
C. Transmission circuit of 20,000 volts
D. Step-down transformer, 20,000 to 500 volts
E. Trolley
F. Trolley wire, 500 volts
G. Ground
H. Synchronous single phase motor
I. Continuous current commutator of 250 volts supplying fields of *H*, *K* and *L*
K. Continuous current generator, 250 volts.
L. Continuous current motor, 250 volts.
M. Reversing rheostat in separately excited field of *K*
N. Driving wheel of locomotive

Operation of Long Distance Railways.

or started under load. It is evident that some form of gearing between the synchronous motor and the axle will solve the problem. Let the synchronous motor drive a direct-current generator and use the current thus generated to supply the motors connected with the axles of the locomotives. This portion of the system is the same as the well-known Leonard system, as applied to elevators. Regulation is secured by varying the field of the generator supplying the motors, and by weakening, strengthening, or reversing the field of this machine any desired speed or direction can be obtained. The continuous-current generator should have its field separately excited. The propelling motors can be series, shunt, or separately excited, but the best results will be obtained by separate excitation. To secure exciting current for the alternating motor and the fields of the continuous-current generator and motor, it will be best to drive by means of the alternating-motor armature, and if desired in the same field, a continuous-current winding connected to a commutator, from which will be led the current for exciting the fields of all three machines. The fields should be wound for 250 volts, and this same voltage used for the continuous-current armatures.

Suppose now the locomotive to be at rest. The synchronous motor is running and driving the generator armature at full speed in a field of no intensity; hence the propelling motors receive no current. The first contact upon the rheostat in the generator field circuit is now made, and let the resistance in the rheostat be such as to produce, say, 25 volts at the generator brushes. This 25 volts will supply a very large current to the motor armature at rest in its saturated field, and consequently will produce a sufficient torque to start the entire load and continue to move it at a slow spoed. There is now being used 25 volts and, say, 2,500 amperes in this circuit; this means 62,500 watts, and disregarding transformation losses for simplicity, this means a current of 125 amperes from the trolley. When operating at the rate of 500 h.p. at full speed there will be needed, say, 1,800 amperes and 250 volts in our propelling circuit, which is 450 kilowatts, and means, roughly, 900 amperes from the trolley. It is evident, therefore, that the load can be started with but a small fraction of the energy required for operation at full speed, and that there will be no danger of throwing the alternator out of step by applying but one-sixth of its full load.

If operating at full speed, and it is desired to bring the locomotive to rest, the strength of the generator field is rapidly reduced by manipulating the rheostat in its field circuit so as to reduce to zero the current exciting this field; the E.M.F. produced by the generator then rapidly falls below the counter E.M.F. of the motors, which are being driven in a constant field by the momentum of the moving load, and the motors consequently become generators and supply current to the former generator, which now becomes a motor, and driving the alternator, feeds current back through the trolley, thereby not only bringing the locomotive smoothly and rapidly to rest but saving the energy usually wasted upon the brake shoes.

Under this arrangement, if steam-engines are used as the source of power, the engines are not subjected to the violent fluctuations ordinarily met with in electric railways, and the capacity of the engines, generators, and conductors can be much reduced over usual requirements.

VOLTMETERS IN ALTERNATE-CURRENT STATIONS.

The subject of using voltmeters in alternate-current stations is treated by Mr. B. Szapiro in the *Elektrotechnische Zeitschrift*. The author remarks on a small correction necessary in voltmeters containing iron when used with alternating currents. He points out that the reading of the voltmeter depends, not merely on the frequency, but also on the shape of the alternate pressure wave. He starts with the general equation:

$$E^1 = E_1 \sin mt + E_3 \sin (3mt + \alpha) + E_5 \sin (5mt + \beta) + \ldots,$$

representing any curve which is symmetrical as regards the axis of abscissæ, and works out values for the effective current; from which he draws the general conclusion that in a certain circuit of given resistance and self-induction the strength of current for a given effective pressure varies with the shape of the pressure curve. In particular, where the self-induction is relatively small the strength of current is independent of the pressure curve; when the curve is nearly a sine function, and the resistance of the circuit comparatively large, no very great difference occurs in the value of current with different E.M.F. curves. But if the resistance and self-induction are of the same order of magnitude, the differences in current-strength may be very noticeable. And in taking the particular case of a Ganz machine the author finds for a voltmeter of resistance 1,000 and coefficient of self-induction = 1 that the error is about 8 per cent. The author therefore advises that all iron instruments should be calibrated on the alternator for use with which they are designed.

Electrical Conductivity of Cupric Chloride Solutions.—Mr. R. J. Holland, in the *Ann. Phys. Chem.*, states that solutions of cupric chloride show a regularly diminishing rate of increase of the conductivity as the temperature rises, and then varies with the concentration, the maximum conductivity being obtained with a solution containing about 18 per cent. of anhydrous salt. The temperature coefficient varies with the concentration, and reaches a maximum at about 40deg.

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ELECTRIC LIGHT PROVISIONAL ORDERS AND TRAMWAY ORDERS AND BILLS.

BOARD OF TRADE REPORT FOR SESSION 1894.

The report by the Board of Trade upon all railway, tramway, gas, and water Bills and provisional orders for the 1894 session has just been issued. We give the following concerning the applications for electric lighting provisional orders and for tramway provisional orders and Bills. Of the former there are 26 applications and of the latter, 13:

ELECTRIC LIGHTING PROVISIONAL ORDERS.

Aberdare Electric Lighting Order.	To authorise J. C. Howell, Limited, to supply electricity within a portion of the district of the Aberdare Local Board.
Barrow-in-Furness Corporation Electric Lighting Order.	To authorise the mayor, aldermen, and burgesses of the borough of Barrow-in-Furness to supply electricity within that borough.
Bedford Electric Lighting Order.	To authorise the Bedford Electric Light Company, Limited, to supply electricity within the municipal borough of Bedford.
Birmingham Electric Light and Power Order.	To authorise the Birmingham Electric Supply Company, Limited, to supply electricity within certain portions of the city of Birmingham.
Buxton Electric Lighting Order.	To authorise the Buxton Local Board to supply electricity within the urban sanitary district of Buxton.
Chelmsford Electric Lighting Order.	To authorise Crompton and Company, Limited, to supply electricity within the borough of Chelmsford.
Chepping Wycombe Electric Lighting Order.	To authorise the mayor, aldermen, and burgesses of the borough of Chepping Wycombe to supply electricity within that borough.
Chesterfield (Corporation) Electric Lighting Order	To authorise the mayor, aldermen, and burgesses of the borough of Chesterfield to supply electricity within that borough.
Clonmel Corporation Electric Lighting Order.	To authorise the mayor, aldermen, and burgesses of the borough of Clonmel to supply electricity within that borough and certain portions of the district of the Clonmel Union.
Collier-Marr Moss Side Electric Lighting Order.	To authorise the Collier-Marr Telephone and Electrical Manufacturing Company, Limited, to supply electricity within the urban sanitary district of Moss Side.
Crystal Palace District Electric Lighting Order.	To authorise the Crystal Palace District Electric Supply Company, Limited, to supply electricity within portions of the district of the Beckenham Local Board, the borough of Croydon, the parish of Lambeth, the district of the Lewisham District Board of Works, and the parish of St. Giles's, Camberwell.
Grimsby (Corporation) Electric Lighting Order.	To authorise the mayor, aldermen, and burgesses of the borough of Grimsby to supply electricity within that borough.
Guildford Electric Lighting Order.	To authorise the Holloway Electricity Supply Company, Limited, to supply electricity within the borough of Guildford.
Harrow Electric Lighting Order.	To authorise the Harrow Local Board to supply electricity within the urban sanitary district of Harrow.
Leyton Local Board Electric Lighting Order.	To authorise the Leyton Local Board to supply electricity within their district.
Monmouth Electric Lighting Order.	To authorise the mayor, aldermen, and burgesses of the borough of Monmouth to supply electricity within that borough.
Oswestry Electric Lighting Order.	To authorise the Oswestry Electric Lighting and Power Company, Limited, to supply electricity within the borough of Oswestry.
Peterborough Electric Lighting Order.	To authorise the mayor, aldermen, citizens, and burgesses of the city and borough of Peterborough to supply electricity within that city and borough.
Plymouth Corporation Electric Lighting Order.	To authorise the mayor, aldermen, and burgesses of the borough of Plymouth to supply electricity within that borough.
St. Austell Electric Lighting Order.	To authorise Veale and Co., Limited, to supply electricity within the district of the St. Austell Local Board.
St. Helens Corporation Electric Lighting Order.	To authorise the mayor, aldermen, and burgesses of the borough of St. Helens to supply electricity within that borough.
Shropshire Electric Lighting Order.	To authorise the Shropshire Electric Light and Power Company, Limited, to supply electricity within a portion of the borough of Shrewsbury.
Stirling Electric Lighting Order.	To authorise the Caledonian Electric Supply Company, Limited, to supply electricity within the Royal burgh of Stirling.
Wakefield Corporation Electric Lighting Order.	To authorise the mayor, aldermen, and citizens of the city of Wakefield to supply electricity within that city.
West Hartlepool Electric Lighting Order.	To authorise the mayor, aldermen, and burgesses of the borough of West Hartlepool to supply electricity within that borough.
Yeadon Electric Lighting Order.	To authorise the Yeadon Local Board to supply electricity within their district.

TRAMWAY PROVISIONAL ORDERS.

Barrow-in-Furness Corporation.	To authorise the construction of additional tramways in the borough, on a gauge of 4ft., to be worked by animal, mechanical, or electric power; and to enable the Corporation to work the tramways in certain circumstances.
Croydon Corporation....	To authorise the construction of tramways in the county borough, to be worked by animal power, or, with the consent of the Board of Trade, by electrical, steam, or any mechanical power; and to empower the Corporation to borrow £2,500, and such further sums as the Board of Trade might sanction.
Croydon (extensions)....	To authorise the construction of tramways in Croydon and Streatham, on a gauge of 4ft. 8½in., to be worked by animal power, or, with the consent of the Board of Trade, by electrical, cable, mechanical, or other power; the erection of posts, wires, etc.; the removal of certain existing tramways; the raising of £40,000 additional share capital, and borrowing of £10,000.
Dudley and Wolverhampton.	To authorise the construction of tramways in Dudley, Wolverhampton, and Bilston, on a gauge of 4ft. 8½in., to be worked by animal power, or, with the consent of the Board of Trade, by steam, cable, electrical, or other traction.
Liverpool, Bootle, and Walton-on-the-Hill.	To authorise the construction of tramways in Bootle and Walton, to be worked by animal or mechanical power
Liverpool Corporation..	To authorise the construction of additional tramways in the city of Liverpool, to be worked by animal, steam, electrical, or any mechanical power; providing for lease to Liverpool United Tramways and Omnibus Company; and for borrowing £5,100.
South Staffordshire.....	To authorise the construction of tramways in West Bromwich and Handsworth, on a gauge of 3ft. 6in., to be worked by animal power, or, with the consent of the Board of Trade, by cable, electrical, mechanical, or other power; and the removal of existing tramways for which proposed tramways are to be substituted.
West and East Hull ...	To authorise the construction of tramways in Hull, on a gauge of 4ft. 8½in., to be worked by animal or mechanical power; and enabling the Corporation of Hull to purchase the tramways.

TRAMWAY BILLS.

Aberdeen District	To authorise additional tramways, including a doubling of existing single lines and certain lines already laid by consent of local authority
Bristol	To authorise additional tramways, being mainly a doubling of existing single lines, to be worked by animal, electrical, or mechanical power.
Harrow and Paddington	To further extend the time for the compulsory purchase of lands and for the completion of the tramways authorised by the Harrow-road and Paddington Tramways Act, 1891.
London Tramways Company, Limited.	To authorise extension tramways, to be worked, with the consent of the Board of Trade, by cable power.
West London.	To incorporate the West London Tramways Company, and to authorise tramways in Acton, Hammersmith, and Fulham, to be worked by electrical or mechanical power other than locomotive steam power; and providing for running powers, and purchase of, West Metropolitan tramways.

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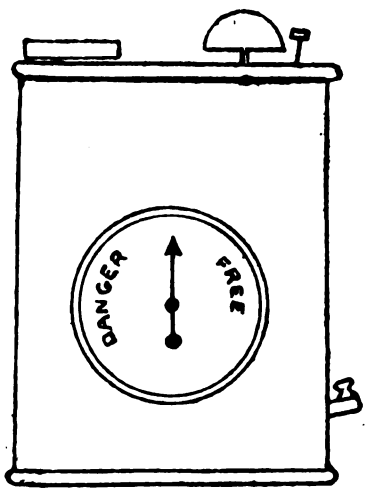
TRADE NOTES AND NOVELTIES.

AN ELECTRIC FOG SIGNAL.

The annual invasion of the fog and smoke fiend means, as we all know, an enormous outlay by the railroad companies upon torpedoes or audible explosive fog signals; and this outlay is almost inversely proportional to the satisfaction and efficiency given by such a method of notifying to engine-drivers the position of semaphore arms which they cannot possibly see. Consequently, there have been endless endeavours made by the railway telegraph engineers, as well as by outsiders, to effect some radical improvement in the methods still used quite generally throughout the country; but the fact that none of these efforts are to be seen in actual extensive working shows clearly that, however excellent may be their theoretical basis, they have no real practical worth.

The one great defect in all these appliances—assuming that they are reliable and automatic in action—lies in the fact that they still offer the same opportunities for mutual mistakes and errors on the part of signalman and driver, as in the case of clear weather and ordinary signals—that is, either the signalman or driver may unwittingly commit an error although firmly believing the contrary, and hence the contradictions almost invariably arising after an accident. Railway men are, as a rule, of a sufficiently respectable class to ensure acting up to their best judgment, and hence the question of wilful misunderstanding may in nine cases out of ten be put aside.

It is, however, most important to nail down an error to the signalman or driver as the case may be, and the apparatus herein noticed has this object in view. Brief descriptions have



already appeared in some of the technical papers, owing to some trials recently held on the Tottenham and Forest Gate Railway—now under construction—but it is difficult to fully appreciate the contrivance without illustrations. We therefore append a small diagrammatic section and elevation of the appliance used with this system, and fixed on the locomotive in order to warn the engine-driver as to the position of signals.

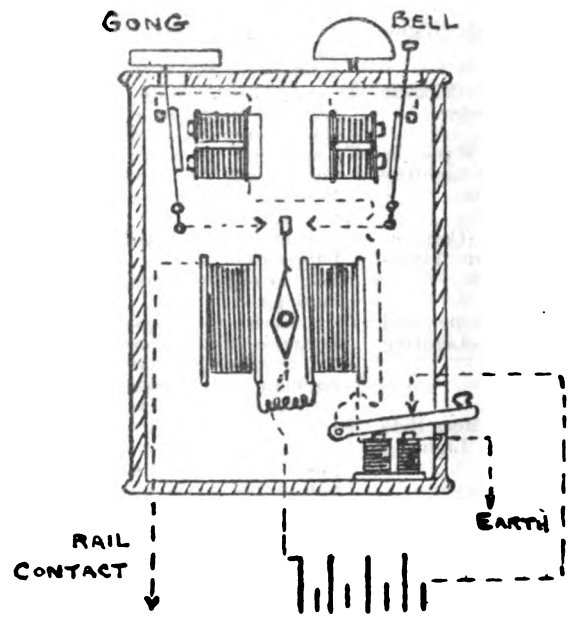
The whole method is the joint invention of Messrs. I. A. Timmis and G. N. Abernethy, and consists essentially of two signal repeaters—one in the cabin and one on the locomotive—in series one with the other, so that any indication on the one is also shown on the second.

Each signal-post is provided with a small primary battery—say, three Leclanché cells—and the signal-arm works a double-pole switch, which sends a current from the battery along a single wire to a repeater in the signal cabin. The double-pole switch determines—by the position of signal-arm—which pole of the battery the current comes from. The circuit goes through the repeater in the cabin, and back along another wire to a long contact-piece placed alongside one of the rails on a block of wood or similar insulating material. So far there is no complete circuit, and the repeater in the cabin does not work; but when the locomotive approaches the signal a contact brush, fixed to the engine frame, travels along the insulated contact-piece already alluded to, and completes the circuit through another repeater on the locomotive, and on through the frame and wheels to earth. It will thus be seen that the repeater in the signal-cabin and that on the locomotive are in series with each other and the signalman is able to act as a check on the engine-driver.

The repeat signal on the locomotive consists of an indicating needle or arm on a dial, and also two bells of different tone, or a gong and a bell; whilst in order to show afterwards what signals have been received on the engine, there is provided an appliance for recording these in connection with the indicator. Similar arrangements are used for the cabin repeat signal, though the bells are not in this case absolutely necessary. Small electric lamps—red and green—might, for instance, be switched in.

The ordinary permanent signal repeaters, such as are usually to be found in signal-cabins, are worked by the same line wire as that which operates the fog repeaters, the two sets being thus in parallel. The advantages claimed for this system are therefore the following: first, the driver knows the position of each signal-arm as he comes up to it, both visually and audibly; second, the signalman is kept equally well informed as to whether each signal is at "danger" or "line clear"; third, he also knows when a train passes a signal; and last, but not least important, a record is kept, according to which the blame for neglect or carelessness may be properly assigned.

Referring to the illustration, it will be seen that when the engine passes over the rail contact a circuit is completed through the large central coils, thereby throwing the dial arm or needle to right or left according to the direction of the current from signal-post battery. This current, it will be remembered, may be sent through the circuit either way by the double-pole switch attached to and operated by the semaphore arm, the dial needle being deflected accordingly. If, for instance, the needle swings over to the left, it makes contact by means of an extension piece above, with one of two contacts also acting as stops. This sends a current from a small battery, carried on the engine, through the magnet coils in the upper left-hand corner, thereby ringing the gong. Similarly, a deflection of the needle to the right sends the local current through the magnet coils at the top right-hand, so as to ring the bell.



In the lower right-hand corner of the apparatus are seen two small magnet coils, with a key lever above them pressing against a contact, through which the local circuit must be completed. In case the engine should come to rest anywhere on the insulated line contact-piece, the driver is able, by depressing the key, to break the local circuit, and thus prevent the gong or bell from ringing uselessly after once giving warning as to the position of signal.

GAS EXPLOSIONS IN ELECTRIC LIGHT CULVERTS.

A report has been made by Prof. Kennedy on the subject of the explosions which occurred in certain junction-boxes in Glasgow towards the end of last year. The professor, who paid a two days' visit to the city and investigated four explosions, concludes that they were due to the accumulation of the gas in the service boxes, the accumulation being such as to eventually form an explosive mixture. Reporting on the explosions, Prof. Kennedy says:

"I cannot doubt that in the case of the explosions on November 9 and 10 the ignitions were actually caused by electrical action. The existence of serious electrical leakage had been shown by the tests at the station for two or three days before the accident, but the position of the leak had not been determined. I feel sure that if any such leakage were to show itself again it would be now possible for your staff to localise it and remove it in a few hours instead of allowing it to go from bad to worse for several days. The primary cause of the accident of November 9 was a piece of exceeding careless work in connection with the main-laying, which had unfortunately passed without detection. The more serious trouble of November 10 was due to a potential lead, the copper in the troughs being dead at the time. The several explosions which occurred during the work of main-laying, and also that on December 29, were, of course, due to the simple ignition of an explosive mixture by a naked light. The cause of the explosion on December 26 is not at all clear. There is absolutely no evidence that it was electrical, and the conditions are such as to render an electrical ignition so extremely improbable that I think the explanation of a chance ignition by a match thrown down—although not at all satisfac-

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tory—is, on the whole, a less likely one. I am sorry that the result of my investigation as to this matter is so entirely negative. The accidents which have occurred, with the possible exception of the first one in Mains-street, have been in no way connected with the use of troughs or of pipes. It has always been the accumulation of gas in the service boxes which has been the cause of explosion. Even under ordinary circumstances it is, of course, impossible to prevent some leakage of gas from gas-mains. Under the existing condition of the Glasgow streets, however, in connection with the various underground works which have been going on, all difficulties of this kind are increased tenfold. Under these circumstances it is undoubtedly necessary that the greatest watchfulness should be shown as to the state of the boxes, especially those near which leakage of gas is known to exist. I have no doubt that the gas department is ready to take advantage of all indications of leaks shown by smell in the service boxes, and to localise and remove them as rapidly as possible."

The following precautions are recommended in the hope that they will so minimise the risk of explosion from the ignition of gas leaks that the authorities need not have further anxiety on this account :

"The covers of all boxes in which any gas leak has been found or is suspected, and also the covers of all boxes towards which gas would naturally ascend if it leaked into the pipes or troughs, should be periodically lifted and the boxes carefully examined. The examination would be best made with a little hand battery lamp, from which there could be no possible risk of ignition. It would be advisable also to use a gas detector in these examinations, as this appears to be more certain in its indication than the sense of smell alone. All boxes should be kept clean and dry. There had been a very great leakage of mud and dirt into several which I examined. I cannot say—but an examination would at once show—whether this mud came down through the joint between the cover and its frame, through the joint underneath the frame, or actually through the walls. I think, however, most of it came down from the top. This can be easily remedied by a more complete jointing of the covers in their frames—this is, I am sure, essential, in spite of the additional trouble it entails every time the cover is lifted—by making quite certain that there is a good joint below the frame on the top of the brickwork, and, if necessary, in any special cases, by cementing the whole of the brickwork on the inside. I attach very great importance to the state in which the boxes are kept, for I think this is very much more than a mere matter of tidiness. Unless the boxes are well kept, one can never be sure that they are properly examined, as the men will always shirk going down into them. Moreover, any joint below the surface which could let mud or water enter would also allow of the easy entrance of gas. If there are any signs in particular boxes that the gas rises up through the floor, the bottom should be treated as a number were treated during the construction of the mains—*i.e.*, it should be covered with cement concrete and drained through a trap to the nearest sewer. Various plans have been proposed for ventilating the boxes and mains generally. To ventilate them by connecting them to a chimney—*i.e.*, by reducing the air pressure all over them—would be, I think, a mistake, for it would necessarily be the means of drawing in gas, and not of keeping it out. To ventilate them by keeping a flenum in them by means of a fan (supposing that this could be done) would, of course, prevent gas from getting in ; but it would have the somewhat serious drawback that it would be liable to send any gas that did get in, or any foul air of any kind, into the houses, through the service pipes. It could hardly be supposed that these would universally be so plugged up, and would remain so plugged up, that nothing could pass through them. I think that probably there would not be any really serious risk from this, but I feel sure that it would be very much disliked by your consumers, and that there would be many complaints about it whether their causes would be real or fancied. The most practicable method of ventilation appears to me to be the ventilation of individual boxes by pipes carried up the side of adjacent buildings. I have also reason to believe, unofficially, that this method would meet with the approval of the advisers of the Board of Trade. I think, therefore, it is desirable that you should adopt it in connection with some of the boxes in the centre of the city where the gas leakage into the soil is largest, and also at other places where there are boxes at the top of inclines, or any places where, for any reason, gas may or may be likely to accumulate. Of course, I am aware that such ventilating-pipes cannot be carried up the sides of buildings without permission, but I hardly suppose that there can be any practical difficulty in getting such permission in a reasonable number of places. The suggestion has been made by one of the authorities in London that each suspected box should be connected by a short pipe to a small cast-iron box, open through a grating (in the pavement) to the atmosphere. This little box would be itself connected to a neighbouring gully or drain to carry off the water and mud which would fall into it. There is obviously no difficulty in carrying out this suggestion, which I mention because of its apparent reasonableness. If, however, from any cause the plan failed at any time to keep the box free from gas accumulations—as I fear it might fail—it would then become an obvious source of danger from chance ignitions on the pavement. A suggested modification of this plan—the use of two separate grating boxes on opposite sides of the brick box, in order to ensure a through draught—is an improvement, and would certainly be very much safer, although more costly. I think it might properly be adopted in cases where the permission to ventilate as I have above suggested could not be obtained."

THE COMMERCIAL PROGRESS OF ELECTRICITY.

A letter on this subject has been addressed to the *Times* by Major S. Flood Page. The letter is as follows :

Those who are connected with electrical trade are constantly being asked by those whom they meet in society, or when travelling, or in the course of general business, whether there is any real commercial progress in the electrical industry. That we have made decided and considerable advance is well known in the trade itself, most of us being very busy, and is not a matter of doubt to those who read the technical journals ; but as the public generally have not access to our admirably-written and well-conducted electrical weeklies, and as we are constantly challenged as to the progress we are making in the most modern application of science to industry, perhaps you will grant me a little space in your columns in which to report progress.

Let us cast one glance backwards as to the date from which electric lighting as we know it really commenced. In August, 1877, a small body of men were invited by Messrs. Dennayrouze and Co., of Paris, of whom only three were Englishmen, to witness an exhibition of the Jablochkoff candle lamp. Never shall I forget our astonishment as this bright, piercing, powerful, and steady arc lamp was lighted up and extinguished. In the spring of 1878, the year of the exhibition in Paris, when our French friends boldly invited Europe to see that they had risen from their recent misfortunes, we all saw the Avenue de l'Opéra brilliantly lighted by the Jablochkoff lamp, which was shortly afterwards in use on the Thames-embankment, though before that, if my memory does not fail me, I was taken to see electric light in use in the offices of the *Times*, one of the very first places in England in which the electric light was in regular and constant use. I think, Sir, the lamp which was in use in the *Times* office was the Rapieff. We may then date the birth of modern electric lighting from the spring of 1878—only 16 years ago. The incandescent lamp was not yet in use. Sir William Thomson (Lord Kelvin), when under examination before a Parliamentary Committee on May 23, 1879, said : "I believe the Jablochkoff candle is the most advanced sub-division of the electric light which we yet have." Mr. Edison's key patent for incandescent lamps was dated November, 1879 ; Mr. Swan's, January, 1880 ; but it was not until 1881 that the manufacture of incandescent lamps became of any importance. A few were made in laboratories, a fair number in experimental factories before that date, but not many were seen in practical use before the Paris Electrical Exhibition in 1881, and in England at the Crystal Palace Exhibition in 1882. So that for practical purposes we may take it that electrical lighting on a commercial scale is not more than 12 years old.

I need not touch on the progress of telegraphs, on which the country has spent several millions of pounds, the expenditure on telegraphs being £2,739,010 for 1893-94, for that, though electrical, is an old story and dates from 1839, or submarine cables dating from 1858.

Neither is it necessary to dwell on the wondrous development of telephones—on which nearly £5,000,000 have been spent by the company and the Government, by which messages have been spoken in the past year to an extent not far, if anything, short of 200,000,000, at, I suppose, an average cost of about a halfpenny, many of the conversations lasting some minutes—except to protest against the muddle which the Government has introduced into telephonic business, to the serious hindrance of business and of progress, and to express the opinion, not for the first time, that the sooner the Government purchase the whole of the telephonic interests the cheaper will be the price to be paid, and the more efficient will the service be made. Nor shall I refer to the great and immediately future question of traction which will greatly suffer unless wisdom is shown and concession of the authorities granted in the regulations which are now being drawn up by the Board of Trade in consultation with the Institution of Electrical Engineers and those concerned with electrical traction ; but I limit myself almost entirely to the progress of the supply of electricity for lighting and for motors, as exemplified in the position of the electric supply companies in the United Kingdom.

At the present time we have some 60 supply companies engendering and supplying electricity, of which 19 are the property of, and worked by, local authorities, 41 by limited companies ; the amount of capital may be taken as about £5,125,000. As much work is in progress and fresh stations are being constantly opened, it is difficult to be exact as to the amount of capital expended ; that which is right to-day will be incorrect in a month.

In addition, 24 local authorities have stations in course of construction, and some 20 companies and local schemes have been sanctioned. These two heads give a further sum as being spent, or about to be spent, of, say, £1,350,000, so that it will not be far wrong to say that the amount expended, or being laid out, or shortly to be spent in electric stations reaches about £6,500,000.

When we come to consider results, we must bear in mind that local authorities do not aim at paying dividends, as when the local authorities own gasworks some strive to sell gas at the lowest remunerative rates. So do they naturally act with the electric stations. Nevertheless, many of the results are fairly satisfactory, and considering the infantine position of local authority supply stations may be considered very hopeful.

Some of the supply companies have not been working long enough to give results yet, and naturally those who can afford the luxury of having their houses fitted for the reception of an electric supply wait to see how their more enterprising neighbours like the light, and how much it costs, before themselves incurring

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the expense of having their houses wired. So that there are very few companies, and none in their earliest years, who are able to sell the whole of the electricity they can engender for lighting, and so backward are we in the use of motors that very few companies are able to dispose of the electricity which could be engendered during the day and sold at a very cheap rate.

Obtaining my information partly from the electrical journals, and partly from Skinner's Stock Exchange Book, and from reports of various companies, the secretaries of which with courtesy do me the favour, without application on my part, of sending me their reports, I conclude that some 18 companies have paid dividends for the years 1892-93 (some only paying a dividend on preference stock) varying in amount from 2½ to 7½ per cent. That nearly every well-managed supply company will eventually pay dividends I have no reasonable doubt; that any of them should pay any dividend in their early days, and that some should pay a fair dividend, is most hopeful and encouraging.

I can well believe that our gas company friends may say I am easily satisfied, that our dividends are paltry, that we live on hope, and, in the assurance of their own steady dividends, can laugh and pour contempt on our humble efforts. But our progress has been phenomenal when compared with that of gas. On May 13, 1879, Mr. Corbett Woodall, M.I.C.E., engineer-in-chief of the Phœnix Gas Company, gave evidence before the Parliamentary Committee to which I have already referred, and said "As a rule in early years gas companies did not pay any dividend at all, or a very small one. Before coming away I sought to find the dividends paid by my company since 1824. I was unable to find them up to 1851, but I believe they never reached 3 per cent. before 1851." That is for 27 years. Surely we have good ground for hope.

At any rate, we have advanced far beyond Mr. Woodall's expectations, for he went on to say that he had no fear that electric light would compete with gas inside houses, as no system had been heard of by which a company could lay wires and send off branches into separate houses or premises, and that it would be necessary to have telegraphic communication from the user to the producer in order that the light might be turned off when no longer required.

I do not recall this gentleman's evidence with any notion of blaming him that he was unable to see how very nearly the whole problem was to solution, when neither he nor other intelligent scientists and engineers believed it was capable of solution; but as a measure or standard by which the extraordinary and unexpected progress which has been made in electric lighting can be gauged when so eminent a professional man committed himself to such opinions no further back than May 13, 1879—not 15 years ago.

While there is nothing novel in this letter, I trust it may show some of your readers that the progress in electric lighting is steady, is real, and that the industry is worthy of support, and that, where strong foundations are laid, there is good hope, with good management, of a fair and progressive return on money invested in such electric companies.

I cannot occupy your space by reference to the vast amount of work which electricity has found for engineers, engine-makers, boiler-makers, wire-makers, and the manufacturers of electrical fittings, apparatus, and instruments, which is not to be despised in these days of dull trade, as these branches give work to many thousands of people.

In conclusion, permit me to say that it seems as if the problem of electrical locomotion on existing lines of railway, and on tramways, is on the point of solution without any alteration of the present lines of railway and of tramways, by means of a great step in advance which has been made by a couple of able French practical engineers, and if my expectations in this respect are not too sanguine—and I have some confidence in their soundness—this advance must also have a very great effect on the progress of electric lighting.

The electrical success of the South London Railway and of the Liverpool Overhead Railway are as gratifying as indisputable.

COMPANIES' MEETINGS.

HOUSE-TO-HOUSE ELECTRIC LIGHT SUPPLY COMPANY, LIMITED.

The sixth ordinary general meeting of this Company was held at the central station, Richmond-road, Earl's Court, on the 22nd inst. Mr. Henry Ramié Beeton, the chairman of the Company, presided.

The **Chairman**, in moving the adoption of the report and accounts, which were given in our last issue, stated that the history of the year could be shortly told. There had been a steady growth of business, and there was a greater rate of progress during 1893 than during 1892, though not to the same extent as in 1891. The Company had been affected by the general depression in trade, as possible consumers had postponed adopting the electric light. The income per lamp had fallen off, the causes being partly temporary and possibly partly general. The temporary cause was to be found in the absence of fog, and a permanent cause was to be found in the fact that consumers were becoming very clever in economising, and it was therefore natural that the income per lamp should be less. There was, however, a satisfactory feature in the accounts, that the Company had earned an increased income at a decreased expenditure. This gratifying point was mainly due to the efforts of Mr. William Page. They had had to face the coal strike last year, but owing to the arrangements which had been entered into the effects had not been great. Mr. Beeton stated that the Company had been very much complimented on the quality of the light which they produced. Capital had been expended on new machinery, and the capacity of the station was now in excess of the immediate demand. At the end of the past year there were 28,429 lamps connected, and at the present time they could supply current for a further 5,000 lamps without an increase of plant. The capacity now was 45,000 8-c.p. lamps. With respect to the transfer of the northern area to the local authority, the local authority could deal with it more advantageously, and they had therefore cancelled that portion of the sphere of their operations. The Company had now obtained experience, and they could forecast their future operations. More lights had been connected during the year than in any other, with the exception of the first days, when the potential demand was great.

Mr. William Page, in seconding the adoption of the report, pointed out that during the four years' operations of the Company the profits had steadily increased, and he did not think the price per light could go down much more, it now being about 8s. 7d., as against 10s. a year or two ago. The great source of the improvement in the profits was due to the economy which had been practised at the works. He bore testimony to the excellent way in which the staff had worked.

In reply to Mr. Kember, the **Chairman** stated that they could not undertake to pay dividends on the preference shares half-yearly instead of yearly, but would try to do so. With respect to the debentures he expected that these would be renewed at a more favourable rate of interest.

The report was adopted unanimously, and on the motion of the **Chairman**, seconded by **Mr. William R. Davies**, it was decided to pay a dividend of 7 per cent. on £25,000 cumulative preference shares.

The **Chairman** said that Mr. Robert Hammond, having decided in December last to retire from contracting work and to confine himself entirely to consulting work, had withdrawn from all the Boards with which he was connected, and had retired from this Board. He would, however, act as consulting engineer to the Company.

Mr. W. F. Leese and Mr. W. R. Davies, who retired from the Board by rotation, were re-elected directors. Messrs. Theobald Bros., Miall, and Co. were reappointed auditors.

EASTBOURNE ELECTRIC LIGHT COMPANY, LIMITED.

The annual meeting was held last week, Alderman Boulton (chairman of directors) presiding.

Mr. Towner (the secretary) read the report of the directors, of which the following is a summary:

The gross profit for the year, after allowing a further sum of £400 for depreciation of machinery, plant, etc., is £1,981. 2s. 2d., of which sum £1,271. 3s. 8d. has been paid for interest on debentures and mortgages, leaving a balance (including £114. 5s. 2d. carried over from last year's accounts) of £824. 3s. 8d. available for dividend. The directors recommend a dividend at the rate of £5 per cent. upon the share capital (free of income tax), which will absorb £508. 10s., and leave a balance of £315. 2s. 8d. to meet the directors' remuneration, and to carry forward a surplus to the credit of the current year's accounts. The reserve fund to meet depreciation now amounts to £1,425. Last year the directors mentioned that the extension of the circuits to the Upperton and Old Town districts was under consideration, and as the suggestion met with the approval of the shareholders the matter has been carefully thought out, and it has been decided to carry it out. The Company's machinery, plant, and mains are in excellent condition. Upwards of 1,300 incandescent lamps have been taken during the year, and a contract entered into with the Eastbourne Town Council for the supply of five additional arc lamps to the Royal-parade, which are now running. The number of lamps at present in use are as follows: arcs, 27; incandescents of 10 c.p., 8,454; as against 21 arcs and 7,136 incandescents in use at December 31, 1892. Mr. James George Langham retires from the board this year, but is eligible for re-election. The auditors, Messrs. Hart Bros., Tibbets, and Co., also retire, but may be re-elected.

The **Chairman** said it was the first time in the annals of the Company they had a satisfactory report with an increasing amount of business and of income. For years past they had been working under great disadvantages—they had been working against apathy and against interests that had been too powerful for them to succeed as they could have wished. He thought, however, they had got over the difficulties now, and the report which the directors presented that day was a highly satisfactory one and reflected great credit on the officers and others connected with the administration of the Company. The gross earnings of the Company had been as follows: 1886, £1,679; 1887, £2,263; 1888, £3,529; 1889, £4,147; 1890, £4,736; 1891 (five quarters), £6,753; 1892, £5,463; 1893, £6,992. That, he thought, showed the Company was in very good fettle, and that they were doing their work well, and satisfactory to the public, because, if not, their increases would not have been so steady. The extension of the system to Upperton and Old Town had very much exercised the minds of the directors, and they believed that a large increase of business would accrue if they could carry out that extension, but, of course, they could not do it without money. They proposed to raise the necessary amount by debentures at 5 per cent., and they had approached the present debenture-holders, who had agreed that any new debentures should rank equal with those they held. He did not like to say

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anything about himself, but he might tell them he was so satisfied with the stability of the Company that he had taken a thousand pounds' worth of the new debentures. What they wanted to do was to raise a sufficient sum of money from them on debentures to enable the directors to carry up the main to the Upperton and Old Town districts so as to get a large increase in their business and receipts. In conclusion, the Chairman proposed the adoption of the report.

Mr. Langham, in seconding the motion, said it was a great satisfaction to him, having interested himself in the movement from the commencement, to find that his prediction that the electric light was the light of the future had become true and was rapidly becoming more true every day.

The motion was unanimously passed, and on the proposition of **Mr. Langham**, seconded by **Councillor Skinner**, it was resolved to pay a dividend of 5 per cent.

Alderman Sutton proposed the re-election of Mr. Langham as director, and this was unanimously carried.

Mr. Hollins proposed that the sum of £200 should be voted to the directors for their services during the past year, and said he was sure all the shareholders must be grateful to those gentlemen for the way in which they had stood by the Company.

Mr. Hurst seconded, and the motion was adopted.

Messrs. Hart Bros., Tibbetts, and Co. were re-elected auditors.

An extraordinary meeting was then held, and the **Chairman** proposed: "That the present first debenture issue of £25,000, bearing interest at the rate of £5 per cent. per annum, be extended with the consent of the present holders of debentures of such issue to £35,000; and that the whole of such extended issue shall bear interest at the rate of £5 per cent. per annum, and that all the debentures forming part of such first issue of £35,000 shall rank *pari passu*, and without priority both as to principal and interest, whether the same shall have been issued prior to or after the date of this resolution."

Mr. Langham seconded, and the resolution was carried, and a vote of thanks passed to Alderman Boulton for presiding.

CHATHAM, ROCHESTER, AND DISTRICT ELECTRIC LIGHTING COMPANY, LIMITED.

The annual general meeting was held last week in the Board-room at the works, Whittaker-street, Chatham. The chairman (Mr. Henry Jasper) presided. The annual report was as follows:

"Your directors, in presenting the sixth annual report and balance-sheet made up to December 31, 1893, have great pleasure in drawing your attention to the continued marked progress of the Company, which now presents prospects of success much more definite than were entertained in the past. At your last general meeting your directors gave hopes that the new management would enable them to pay an interim dividend in June, 1893, and they beg to draw your attention to the fact that the profits made this year would have warranted their doing so. They have, however, decided for the present not to pay any dividend, as they consider that it will greatly add to the future benefit of the shareholders to carry the balance of revenue forward to a reserve fund. Your directors regret, notwithstanding the facility with which other electric lighting companies are obtaining debentures, that not sufficient of the first issue of the debentures of the Company, offered to the public in January last, have been taken up to enable them to proceed with the proposed extension of mains and plant. Could this proposed extension have been carried out, Mr. M. H. Hurrell, your managing director, considers your present profits (after paying interest on debentures) would have been considerably more than doubled this year. We must here call your especial attention to the fact that every promise made by him with regard to our profits has been fulfilled, and this notwithstanding the great loss we have sustained from being unable to take his advice and accept the low tenders for coal offered us before the coal strike of last year. Since the completion of the underground mains, which, however, only covers the same area as that covered by the late overhead system, a number of new customers have been connected, representing an increase of 6,580 candles, and your especial attention is also drawn to the fact that, with the exception due to the stoppage of the Gaiety Music Hall, we have not only retained every one of our customers, but the majority have, since the introduction of the meter system, considerably increased their number of lamps by upwards of 2,000 candles, thus showing their high appreciation of the light, both with regard to its superiority and its price compared with gas. A very considerable increased number of lamps has also been connected since the date of this balance-sheet, and our staff are still fully occupied with this work; but your directors regret to say that they are not able to do nearly as much in this way as might be done, nor can they carry out such, or any further necessary work of the Company, without raising further capital, either as ordinary shares or debentures. Your directors have under consideration the issuing of the first part of our first issue of debentures at a discount, to enable them to proceed with the necessary and pressing work. Mr. William King retires by rotation, but, being eligible, offers himself for re-election. Messrs. J. E. Ratcliff and G. F. Butts, the auditors, retire, and offer themselves for re-election."

The **Chairman**, in moving the adoption of the report, said he did not know that there was much for him to say, as the report embraced the whole of the Company's affairs, and he did not think he could enlighten them much more by details. The directors anticipated that a larger number of lights would have been taken up, but many had not cared to go to the expense of the installation. That matter had now, however, been vigorously taken up by Mr. Hurrell, their managing director, whose great experience enabled him to superintend the work and get the light installed at the very lowest possible cost. A large number of customers had adopted meters in preference to having the light supplied by fixed contract, and were thus able to economise, not paying for light unless it was consumed. The result had proved perfectly satisfactory, and several of the customers had put on additional lights in their establishments. It was expected that before the end of the present year the whole of the consumers would have adopted the system of supply by meter. Another advantage was the reduction in the cost of lamps through the royalties having expired. These things combined had tended to increase the demand for lights, as all of the changes had favoured the consumer. The Company were steadily rising in public favour and confidence. This Company could greatly extend its business with more capital, and the value and extent of their plant and machinery and their business were excellent security. Speaking of how much of their success was due to their managing director, he observed that the Company would have been in a far different position to-day had they such a manager from the first. The directors would have been warranted in recommending a 2½ per cent. dividend, but as money was wanted for extending their mains it was decided not to declare any dividend and to endeavour to get the debenture stock taken up. The earnings of the Company's station had been highly satisfactory, notwithstanding that they had been unable to act upon the managing director's excellent advice and buy up coal prior to the coal strike. When compared with other companies, their record throughout was a highly favourable one. He had much pleasure in moving that the report be received and adopted.

Mr. Church seconded this, and the report was unanimously adopted.

On the proposition of **Mr. Masters**, seconded by **Mr. Church**, Mr. W. King was reappointed a director.

Mr. Massey moved, and **Mr. Williams** seconded, that Messrs. G. F. Butts and J. E. Ratcliff be re-elected auditors. This was supported by the **Chairman** and carried.

HASTINGS AND ST. LEONARDS-ON-SEA ELECTRIC LIGHT COMPANY, LIMITED.

The annual meeting was held last week at the Brassey Institute, Claremont, Hastings, Mr. H. M. Baker, J.P., presiding.

The **Chairman**, in moving the adoption of the report, said that those who recollected the last meeting might remember that attention was called to the fact that they would have during the current year to call up a considerable amount of capital to carry on a larger and increased business. If they would compare the balance-sheet with that of last year they would find that they had called up £5,230 during the year, and that their revenue was increased from £4,276 to £5,390, or an increase of £1,114, which was a little more than 25 per cent. Although that was satisfactory as far as it went, it was only fair to say that it would have been very much more, but as he had explained on the last occasion, a considerable amount of expenditure had been incurred, which would undoubtedly be realised during the current year over the lighting of the whole of the Front Line. As they were aware, the full extent of the lighting was not to take place till midsummer. He took that opportunity of publicly stating the fairness with which the Corporation had met them in all their transactions with them. As regards the increase of the Front lighting, the Corporation represented to them that the gas company considered it only fair they should have proper notice to terminate their contract, and as three months of their last year would be very long days and short nights, they felt that the liberal manner in which the gas company had in times past treated them was such that they could not very well refuse the request of the Town Council to meet their views. The next thing he should like to allude to in the report was to his mind a very important one. That was that they thought it well, in the interests of the shareholders, to secure to themselves the services of Prof. Kennedy. After making every enquiry, they decided to appoint that specialist, and it had proved that their decision had been right. In the same paragraph of the report it went on to say that Prof. Kennedy had examined their plant and works generally, and had approved of everything that had been done. They had arrived at that stage in the history of the Company when their directors believed it would not do to rest on their oars and take things quietly. They believed that a great responsibility must be thrown upon their shoulders or upon some others. Having led them for several years through good report and bad report, they had now arrived at that condition that he did not hesitate in telling them that if they were in a position to supply the light they could sell half-a-dozen times as much as they did now. Up to the present time they had thought it advisable to move slowly, but their directors would have seriously to consider the best means to meet the increased demand which they were receiving on all hands when they wanted more capital. They had asked the shareholders for it, and they had got what they wanted, but whether they would go on in that slow way by degrees would be a matter they would have to consider, and that it would have to be considered very seriously he could assure them. They must not forget, as pointed out to Mr. Langham and himself by the officials of the Board of Trade, they had a very valuable concession in their provisional order, by which they had to supply the whole of that district, and under that provisional order there were certain conditions which sooner or later they would be called upon to fulfil. They had a very valuable property—no one could doubt that—and it was certain that the electric light must be the light of the future.

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Mr. Shorter, who seconded the adoption of the report, thought the shareholders were thoroughly satisfied with the progress the electric light had made.

The report was then adopted, and a dividend of 5 per cent. declared.

The **Chairman** stated that Messrs. F. A. Langham, J. Reeves, sen., and J. Woodhams retired that year by rotation as directors, and they were all eligible for re-election.

The **Rev. J. W. Tottenham** proposed the re-election of the three retiring directors.

Mr. A. L. Ward seconded, and the motion was carried.

Messrs. Hart Bros., Tibbets, and Co. were re-elected auditors, and a vote of thanks accorded to the chairman for presiding closed the proceedings.

BUSINESS NOTES.

Ludgate-circus Post Office.—This new post office is being wired by Messrs. Spagnoletti and Crookes.

Western and Brazilian Telegraph Company.—The receipts for the week ended March 27 were £2,735.

Liverpool Overhead Railway.—The traffic receipts of this railway for the week ending 25th inst. amounted to £797.

Folkestone.—A meeting of the Town Council is to be held to consider a further report of the Electric Lighting Committee.

Waterloo and City Railway.—In reference to the Waterloo and City Railway Company, it is stated that the applications for shares are in excess of the number required.

St. Pancras.—The St. Pancras Vestry have accepted the tender of Messrs. Crompton and Co. for supplying engines and dynamos for the new King's-road station, at £6,917. 9s.

Joseph Mills and Co., Limited.—This Company has been registered with a capital of £2,000, in £1 shares, to acquire the electrical business now carried on by Joseph Mills at Sheffield, and to carry on and extend the same.

Dover.—The surveyor to the Town Council has received from the architect of the electric lighting station new plans giving a more elaborate description, and as the builders want to proceed with the work he has inspected the plans and recommended their adoption.

City and South London Railway.—The receipts of the Company for the week ending March 25 were £792, against £859 for the same period last year, or a decrease of £67. The total receipts for the first half-year of 1894 show a decrease of £80 compared with those for the corresponding period of 1893.

Lighting of Asylums.—In the estimate supplied to a committee of the Barony Parochial Board, Glasgow, the initial cost of lighting certain parts of Woodilee Asylum with electricity was given as £562, as against £440 for gas, and the annual cost at £98, as against £92 for gas. These estimates were brought before the Parochial Board, and it was resolved to fit up the institution with gas.

Messrs. Baxendale and Co.—This Company inform us that they have just secured the following contracts: complete electric lighting plant for the Bromley-street Mills, Manchester; complete wiring for Corporation supply at the Wesleyan Chapel, Nelson; Messrs. W. Thompson and Co., Spring-gardens, Manchester, complete wiring of both establishments for Corporation supply; and Messrs. Smallman's new restaurant, Manchester.

Rebey and Co., Limited.—The estate of a deceased partner (the late Mr. William Mackinder) of this well-known firm of engineers offers for subscription by tender 2,880 fully-paid shares of £10 each. Forms of application can be obtained of the bankers and of the auditors of the Company, or of Messrs. Andrew, Wood, and Co., solicitors, 8, Great James-street, Bedford-row, London, and of Messrs. Andrew and Trotter, solicitors, Lincoln, of whom all further information may be obtained.

Building Trades' Exhibition.—At the Building Trades' Exhibition, which closes to-morrow (Saturday), at the Agricultural Hall, Islington, Mr. Harry South, of 10 and 12, Garrick-street, Covent Garden, is lighting about 90 16-c.p. incandescent lamps. The current is supplied by a Crompton dynamo driven by a Tangyes gas-engine. Messrs. Baird, Thompson, and Co. make a good display of ventilators and ventilating fans, the latter including a fan driven from its own engine.

Islington.—At a meeting of the Vestry last week the clerk read a letter from the solicitor with reference to the purchase of the land for the electric lighting station (Holloway-road site). It stated that the vendor's solicitors had refused to extend the time fixed for the completion of the purchase, 23rd inst., although the abstract was only delivered on the 9th inst., and suggested that a cheque should be drawn for £7,650, payable to the Great Northern Railway. The matter was referred to the Finance Committee.

Bromley.—At a meeting of the Electric Lighting Committee of the Local Board a letter was read from Mr. F. Stevens, clerk to the Beckenham Local Board, enquiring whether the Bromley Local Board would be willing to appoint a small committee to confer with a similar committee of the Beckenham Local Board as to the advisability of constructing electric lighting works to supply the two towns. The committee recommended that Messrs. Davis, Selby, and McIntyre be appointed a sub-committee to confer with the Beckenham members on the subject. This recommendation was adopted.

Country-House Lighting.—The contract for the electric lighting of Merrow Grange for Mr. F. Baring-Gould has been placed in the hands of Messrs. Allpress and Co., of 55, Victoria-street, Westminster. The dynamo will be run by an oil-engine, and accumulators will be used. The engine-house will be built some distance from the mansion, and besides the electric lighting two sets of pumps will be driven by gearing off the engine for delivering into tanks, placed in the house, soft water from an underground reservoir, and hard water from a well, the latter being passed through a Porter-Clark softener.

Lighting at Cardiff.—At a meeting last week of the Lighting and Electrical Committee of the Cardiff County Council, Mr. W. H. Massey (electrical engineer) reported that 14,385 yards of pipe work had been finished, leaving 2,500 yards to be put down. The light will be available in May. Mr. Harpur (borough engineer) said that the committee might consider the propriety of extending the area into Tredegarville, where there were many people who wanted the light. Councillor Brain asked what would be done if someone outside the district applied for the light, and Mr. Massey stated that it was within the right of anyone in the borough to apply for the extension of the mains, and terms were fixed which were fair to both parties.

Hanley (Staffs.).—The following tenders were received for lighting the Higher Grade Schools, Hanley, by electricity, for the Hanley School Board:

Ball and Co., Bristol	£661	7	3
Brush Electric Company, London	588	19	9
Laing, Wharton, and Co., London	586	8	9
Fowler, Lancaster, and Co., Birmingham	557	13	0
Maunsell Mercier and Co., Manchester	475	10	0
J. Blackburn, Nottingham	466	14	8
Spagnoletti and Crookes, London	436	17	0
Verity and Sons, Manchester	398	11	6

The tender of Messrs. Verity and Sons, Manchester, has been accepted.

Industrial Exhibition at Bingley Hall.—The National Trades' and Industrial Exhibition was opened at Bingley Hall, Birmingham, on Saturday. The hall is lighted by the Walsall Electrical Company in conjunction with Messrs. Tangyes. Amongst the machinery, Messrs. Robey and Co., of Lincoln, show their improved gas-engines; Messrs. Tangyes, Limited, have on view gas-engines, one of which is driving a dynamo for the electric lighting of the hall, which they are carrying out in conjunction with the Walsall Electrical Company, who occupy the adjoining stand with a number of electrical appliances for private installations. Other electrical engineers represented are Messrs. Langstone, Young, and Co., Coleshill-street; Mr. J. A. Ewins, Scholefield-street; and Messrs. T. L. Hemming and Co., Snow-hill.

The Deansgate Hotel, Manchester.—Messrs. Maunsell Mercier and Co., of 5, Deansgate, Manchester, have secured the contract for wiring, fittings, and complete plant for about 600 16-c.p. lamps for this hotel. The generating plant will consist of two 30 b.h.p. "Premier" gas-engines and two dynamos driven from countershafts. To minimise the risk of failure (no gas being put in) two circuits will be run all over the building, and the lamps will be alternately on each circuit. The main switchboard will have two voltmeters, two ammeters, two double-pole main switches, and 18 two-way branch switches, so that any circuit may be switched on to either machine. Provision will be made in the engine-house for a spare engine and dynamo. The architects are Messrs. Moffat and Bently, of Whitehaven.

Electricity and Photography.—Messrs. R. and S. J. Lawson, of Railway-arcade, Shepherd's Bush, W., send us the following cutting: "Electricity plays a very important part in the photographic world to-day. Not only are studios and showrooms illuminated by the incandescent lamp—even the darkroom is invaded, and most lampmakers now lay themselves out to supply some contrivance for filtering the light through a ruby or orange medium. Messrs. Shippey Bros., of 13, King-street, Cheapside, adopt the plan of encasing the bulb in an outer glass case, and filling the interstice with a deep ruby fluid, through which the light passes in an agreeable fashion. The lamps are made in all voltages, from 1 c.p. upwards; and special holders have been devised to accommodate the double bulb."

Church of St. Nicholas Cole-Abbey.—This City church is lighted by electricity, the contract having been carried out by Messrs. Henry F. Joel and Co. The main body of the church is lighted by 11 200-c.p. incandescent lamps, with the lamp bulbs obscured or frosted to soften the light, giving an effective light of 150 candles. The lamps are fitted in artistic glass shades, with wrought-brass scrolls, designed by Mr. J. Aldam Heaton. The lamps are pendant lamps, and are so arranged that they can be lowered from the roof for cleaning or other purposes. Each lamp has a controlling switch in the vestry, where the verger turns them "on" or "off" as previously agreed upon with the rector. There is one 200-c.p. lamp in a globe outside the principal entrance, and 16 smaller lamps of 16 c.p. distributed in the vestries, entrances, etc.

Costly Light.—Under this heading "Pgh" has written to the *City Press* as follows: "Is it not time for one of our representatives to move the Corporation to take the opinion of the citizens on the subject of excessive gas and electric lighting charges? You are doubtless aware that parishes outside the City are holding meetings in condemnation of the Gaslight and Coke Company charging their customers 3s. 1d. per thousand on the north side of the Thames, and 2s. 5d.—or about 27½ per cent. less—on the south side. It is also worthy of note that in St. Pancras the

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charge for electric light is 6d. per unit, while in the City it is 8d., or 33 per cent. more. I think you will agree that the citizens have a right to expect their representatives to make an earnest effort to protect the interests of their constituents by seeing that gas and electric light are given to them at the lowest possible price."

Bournemouth.—At a meeting of the Town Council last week the Lighting Committee, having considered the report received from Major Cardew as to the accident by which a horse was killed, recommended that the town clerk should write to the Board of Trade asking what steps had been taken by the electric supply company towards carrying out the suggestions contained in the report. The same committee reported the receipt of a letter from Messrs. Martin and Leslie, parliamentary agents, stating that the Board of Trade proposed to issue the license to the Town Council in the form which they enclosed with the present letter. The committee recommended that a voltmeter be purchased and fixed at the municipal buildings at an estimated cost of £15. The reports were adopted, but later in the meeting the Mayor announced that Major Cardew had arrived in Bournemouth that day to enquire into certain matters which had recently occurred in connection with the working of the electric light system.

Ignition Tube for Gas-Engines. — Bearing the title of "Wellington's Indestructible Ignition Tube," a new tube for gas and oil engines has been introduced by the Indestructible Ignition Tube Syndicate, Limited, of 100c, Queen Victoria street, London, E.C. The tubes are made in different shapes and sizes so as to suit various gas-engines. Some tubes are provided with a collar at their base, whilst others have a trumpet-shaped end A special gunmetal union is provided for each type of tube, and the joint is made with a little red lead. The tube is the result of research into the various silicacious earth combinations, which, when properly arranged, form a mixture having great refractoriness, combined with the power of resisting pressure at high temperatures, and of acquiring a white heat almost simultaneously. The makers claim that the endurance of this tube has been proved at 15 months' continuous working ; that it only requires two minutes to attain a bright red heat ; and that it can be fixed to any gas-engine.

Assessment of Electric Light Works.—At a meeting last week of the City of London Union, the Assessment Committee reported that their attention had been called by the vestry clerks of certain parishes to the effect that the electric company's works were in a very forward condition, and should, in their opinion, be valued for the purposes of assessment. The committee had decided that the work was in the nature of a public undertaking, and that the valuation by each parish separately would necessarily be of an unsatisfactory and very costly nature. They recommended that Mr. Walter Barnett, of Winchester House, should be appointed to value the undertaking as it now stood, supply detailed maps or plans, together with a detailed report of all buildings, mains, works, and the whole of the mains and any other property belonging to the company ; attend upon the committee and upon any of the vestry clerks and overseers of the various parishes, attend at court if necessary in the event of appeal, and ascertain the proportion properly chargeable to each of the 112 parishes in the union, at an inclusive fee of £420. The report was agreed to.

Shiplighting.—There has been launched from the yard of Messrs. W. B. Thompson and Co., Limited, Dundee, a screw-steamer named the "Fingal," for passenger and cargo trade between Leith and London. The vessel is 290ft. 6in. long, 35ft. beam, and 18ft. 2½in. deep. The state-rooms are handsomely furnished, and have each communication with the steward's department by means of electric bells. The steam steering-gear engine is controlled from the bridge, and telegraphs communicate with the engine-room. The electric light equipment is supplied by Messrs. W. C. Martin and Co., Glasgow, and will be one of the most complete ever fitted on board a passenger steamer of the size of the "Fingal." The installation will include two sets of direct-acting engines and dynamos. Each section of the ship will be lighted by interchangeable appliances from either dynamo, so that a duplicate supply is available in the event of any mishap. The fittings for the saloon and social hall are of choice design, in rich cut-glass shades and lamps, tinted in a variety of colours, and the promenade decks and other parts of the ship will all be brilliantly illuminated. The mast and side lights will be Martin's patent duplicate electric system, and tell-tale indicator on deck bridge.

Buckingham.—At a meeting of the Town Council last week, the Mayor said the first question on the agenda was to consider the recommendation of the Lighting Committee to the effect that the gas company be offered 4s. 2d. per 1,000 cubic feet for gas to be supplied by them during the current year, being the price charged in neighbouring towns. Alderman J. W. Thorpe rose and proposed that the recommendation be adopted. Councillor Barnes seconded the proposition. Councillor Holland thought it would be advisable to hear the terms to be offered by the electric light company before they proceeded with this proposition. Other members thought otherwise, but there being no amendment, the proposition was declared carried. The Mayor said the next item was to consider the tender from Messrs. Parr and Gillies for electric lighting of certain lamps. The town clerk produced the tender, which offered to continue to light the lamps over the entrance to the town hall and the post office, and also the eight others in and adjoining the Market-square, at the rate of long-time lamps £1. 4s. each, and short-time lamps 12s. 8d. each, per annum. In reply to a question, the Mayor said the gas company were paid £1. 10s. for long-time and 14s. 7½d. for short-time lamps. Councillor Holland said he had no objection to the lighting of the lamps by electricity, but he did not like the lamps being confined to the specified area, because in case of a mishap the whole of that part of the town would be in darkness. Councillor F. Higgens moved that the tender be accepted, and Alderman J. W. Thorpe seconded the proposition, which was carried.

Result of Cheltenham Tenders.—The following tenders were received by the Corporation for supplying and erecting engines, dynamos, and boilers at the central station :

	Whole.	A.	B.	C.
Laing, Wharton, and Down (B. and L.)	£4,964	£360 0	£4,002 0 0	£682
Siemens (Belliss, D.)	4,360	365 0	3,450 0 0	590
Siemens (Willans, D.)	4,610	365 0	3 695 0 0	590
J. Fowler and Co. (Fowler, R.)	4,500	377 0	3,612 0 0	575
Johnson and Phillips (B. & L., B)	4,307	345 0	3,280 0 0	682
Crompton (B. and L., R)	4,100	430 0	3.060 0 0	660
Crompton (D. P. and R.)	4,125	430 0	3,100 0 0	660
Crompton (Belliss, R)	4,180	430 0	3,163 0 0	660
Crompton (Belliss, D.)	4,170	430 0	3,160 0 0	660
Crompton (Willans, D.)	4,470	430 0	3,460 0 0	660
Brush Co. (Brush, D. and R.)	3,840	340 0	3,006 0 0	521
Galloways	—	438 15	—	—
Spurr, Inman, and Co.	—	340 0	—	—
Willans (Willans, D.)	—	—	3,963 0 0	—
Electric Construction Corporation	—	—	3,400 0 0	—
McLaren (McLaren, R.)	—	—	3,322 10 0	—
Mather and Platt	—	—	3,255 10 6	—

Note.—B. and L. is Browett and Lindley engines, D is direct driving, R is rope driving, and B is belt driving. The tenders of Messrs. Siemens Bros., at £4,245, and of Messrs. Galloways, Limited, at £877. 10s., have been accepted.

Rockhampton Gas and Coke Company, Limited.—The report of the directors for the half-year ended December 31 last congratulates the shareholders upon the business done. Notwithstanding the general depression that has prevailed, necessitating economy on the part of the Company's customers in their use of the gas and electric light, the profit is greater than for the corresponding half of last year. The gas operations show a profit of £2,006. 13s. 9d. The electric light operations show an actual loss of £21. 9s. 4d., to which is added £294. 2s. 11d., interest upon the capital invested in the electrical plant and buildings, making a debit balance of £315. 12s. 3d. The net profit arising from the whole of the Company's business is £1,691. 1s. 6d. The lighting of the Fitzroy Bridge with powerful electric arc lamps, referred to in the last report, is now in operation. Numerous applications from business people have been made for high-power arc lamps for outside illumination, and the directors are importing suitable lamps for this purpose. A section of the Company's amended Act provides that the retention of the power to supply Rockhampton with the electric light is dependent upon the Company commencing operations and installing the light to the satisfaction of his Excellency the Governor-in-Council, and of the Council of the Municipality of Rockhampton, within five years of the date of the passing of the said Act. The directors report that the Governor has intimated his satisfaction and approval of the work done by the Company in this direction, and the Rockhampton Municipal Council has passed a resolution expressive of its entire satisfaction of the manner in which the light has been installed. The special conditions of the Act having therefore been complied with, the Company's powers in respect of electric lighting in Rockhampton and North Rockhampton are now finally confirmed. The directors, after careful consideration, are of opinion that the debit balance of the electric light operations can fairly be written off the general reserve fund, and they recommend this being done. They recommended that a dividend at the rate of 10 per cent. per annum, amounting to £1,997. 4s. 4d., be paid out of the profit arising from the gas operations for the half-year.

Lighting of Guildford.—A meeting of the Town Council was held last week to further consider the question of the electric lighting of the borough, the subject having been adjourned from the previous Tuesday. Since the last meeting the General Purposes Committee had held another meeting, and the town clerk (Mr. F. F. Smallpeice) read the following report: "The General Purposes Committee report that since the meeting of the Council held on the 13th inst. they had given further consideration to the question of the application which is now before the Board of Trade for the granting of a provisional order for electric lighting in the borough, and they are still of opinion that the supply of electricity in the borough should be in the hands of the local authority. As the committee are led to believe that the promoters are willing to have clauses inserted in the provisional order which will enable the Town Council to take over the undertaking at some future time on equitable terms, they recommend the Council to agree to withdraw their opposition to the granting of the provisional order on condition that clauses to the following effect are inserted therein: (1) a clause empowering the local authority to acquire the undertaking for a sum not exceeding £350 at any time within three months after the commencement of the order; (2) a clause providing that in the event of the Town Council exercising the power given them by the preceding clause, the period for carrying out the compulsory works be extended to three years from the commencement of the order ; (3) a clause providing that the local authority may acquire the undertaking after the expiration of the period above mentioned and before the expiration of a period of 42 years from the commencement of the order on terms similar to those inserted in the Oxford provisional order, but with a modification that the payment of the purchase-money or consideration for the undertaking in such event shall be made in cash and not in bonds or stock." The Mayor moved the reception and adoption of the

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report, which was seconded. Councillor Wrist moved as an amendment that Clauses 1 and 2 of the report be omitted. This was seconded, and after some discussion the amendment was lost by eight votes to six. The resolution was then put, and was lost by seven votes to five. Alderman Allen said that if the opposition were carried forward the probability was they might get a reduction of the 42 years; whereas if there were no opposition they might find that they could not in the interest of the ratepayers obtain the purchase under 42 years. He proposed that the town clerk be instructed to carry forward the opposition, notice of which has been given to the Board of Trade. Alderman Swayne seconded, and the motion was carried.

Inauguration of the Oldham Station.—This station has just been set in operation, the ceremony being performed by Miss Smith, daughter of the Mayor. There was a numerous attendance, including the Mayor and Mayoress, Alderman Hall, Councillors Bolton, Shaw, Nield, Harrop, Ingham, and W. H. Holt, Prof. Kennedy, Mr. Newington (resident engineer), Mr. H. Andrew (gas and water superintendent), and Mr. J. Chadwick (gas manager). After the current was turned on, the Mayor gave an explanation of the scheme. He said that in 1890 application was made by the Corporation for a provisional order to enable them to supply electricity. The provisional order passed the Board of Trade in due course, and on August 4, 1890, was confirmed by Parliament. A committee was then appointed to obtain information from other towns with respect to the supply of electricity, and an electrical expert was engaged to advise the committee as to the best scheme to adopt, and Prof. Kennedy was retained for this purpose. In 1892 an application was made to the Local Government Board to confer powers upon the Corporation to borrow money to carry out the requisite works for supplying electricity, and a Local Government Board inspector held an enquiry in August of that year, and in the September following the Local Government Board approved the scheme and sanctioned borrowing of £27,000 for electric lighting purposes, repayable in 25 years. Tenders were obtained for the undermentioned works, and the following were accepted: for the erection of the electric lighting station, Messrs. S. and J. Smethurst; dynamos, engines, fittings, switchboard, instruments, and connections, Messrs. Charlesworth, Hall, and Co.; steam-boilers, the Oldham Boiler Works Company; batteries, etc., the Crompton-Howell Electric Storage Company; economisers, Messrs. Green and Son; insulators, Messrs. Doulton and Co., London; and Messrs. Siemens Bros., Limited, and Henley's Telegraph Works Company for cables. The laying of the mains and the construction of the conduits in the streets was executed by the Corporation under the supervision of their electrical engineer, Mr. Newington, Mr. Chadwick, the gas manager, and Mr. Herbert Andrew, the superintendent of the gas and water departments. The Mayor then read a report which had been prepared by Prof. Kennedy. In conclusion, his Worship remarked that the total tenders amounted to £13,678. 10s.; the making of street mains and conduits, £6,000; service lamps, meters, etc., £600; balance to pay, £5,214; or a total cost of £25,070. It had been suggested that they might utilise the steam generated at the destructor, but that was a matter the committee could consider at some future time. On the motion of Prof. Kennedy, seconded by Councillor Taylor, a vote of thanks was passed to Miss Smith and the Mayor, and the members of the committee then visited the different parts of the town where lamps had been fixed.

PROVISIONAL PATENTS, 1894.

MARCH 19.

5690. **Improvements in connection with microphones.** Hermann Oppenheimer, 55, Redcross-street, London.

5721. **New or improved process and apparatus for the electrolytic decomposition of common salt.** Castle Smith, 54, Fleet-street, London. (Gersdorf Jorgensen, Norway.)

MARCH 20.

5728. **Adapting electromotors to dental purposes.** William Routledge, 46, Low Friar-street, Newcastle-on-Tyne.

5735. **Improvements in electrical switchboards.** Edward James Paterson and Claude William Hill, European Works, Pownall-road, Dalston, London.

5754. **An improvement in electrical arc lamps.** William Harding Lauder, 33, Blessington-street, Dublin.

5796. **Improvements in underground conduit systems for electric railways.** Herluf August Frederik Petersen, 18, Southampton-buildings, Chancery-lane, London. (Complete specification.)

5806. **An improvement in dynamo-electric machines and apparatus for driving them.** Arthur Salisbury Baxendale, 28, Southampton-buildings, Chancery-lane, London.

5807. **A duplex electrical safety fuse.** The Edison and Swan United Electric Light Company, Limited, and Charles Faraday Proctor, 28, Southampton-buildings, Chancery-lane, London. (Complete specification.)

5816. **Improvements in electrical measuring instruments.** Henry Harris Lake, 45, Southampton-buildings, Chancery-lane, London. (Edward Weston, United States.) (Complete specification.)

MARCH 21.

5863. **Improvements in fuse-boxes for electricity supply mains.** Henry Reason, 111, Gloucester-road, Brighton.

5913. **Improvements in alternators.** John Smith Raworth, 46, Lincoln's-inn-fields, London.

5917. **Improvements in and relating to telephone and telegraph systems.** Sir Charles Stewart Forbes, Bart., 45, Southampton-buildings, Chancery-lane, London.

5918. **Improvements in arc lamps.** Samuel Sealy Allin and William Henry Wood, 52, Woodstock-road, Bedford Park, London.

5921. **An improved telephone combination.** Sir Charles Stewart Forbes, Bart., and the Domestic Telephone Company, Limited, 21, Finsbury-pavement, London.

5922. **An improved automatic electric machine.** Alfred Howard, 10, Clifford's-inn, London.

5931. **Improvements in electrically-propelled common road vehicles.** Ernest John Clubbe and Alfred William Southey, 53, Chancery-lane, London.

5932. **An improvement in electrically-propelled vehicles.** Ernest John Clubbe and Alfred William Southey, 53, Chancery-lane, London.

MARCH 22.

5971. **Improvements in apparatus for the use of the electric light for photographic purposes.** Andrew George Adamson, 154, St. Vincent-street, Glasgow. (Complete specification.)

5989. **Improved method of and appliances for manipulating search-light projectors.** William Elworthy, 73, St. Stephen's-road, Upton Park, London. (Complete specification.)

6028. **An improvement or improvements in electro-dynamo machines and in electromotors.** Samuel Jevons, 7, Staple-inn, London.

6046. **Improvements in the methods of effecting the electrolysis of saline solutions.** Louis Alphonse Paul Liénard and Henri Eugène Albert Liénard, 40, Chancery-lane, London. (Date applied for under Patents, etc., Act, 1883, sec. 103, 22nd September, 1893, being date of application in France.) (Complete specification.)

6057. **Improvements in electrical conductors and in the method of making connections between electrical conductors.** Henry Edmunds, 47, Lincoln's-inn-fields, London.

MARCH 24.

6089. **Improvements in the means of protecting electrical conductors.** John Augustine Kingdon, 29, Marlborough-hill, St. John's Wood, London.

SPECIFICATIONS PUBLISHED.

1893.

2740. **Electric arc lamps.** Rathbone.

4685. **Recording and reproducing tapes for electrical ticker machines, etc** Bott.

6170. **Earthenware electric switches, etc.** Hollins and Meir.

7082. **Brackets for electric lighting, etc.** Ketley.

7594. **Electrolytical decomposition of chlorides.** Lyte.

8571. **Cells for electric batteries.** Emery.

8812. **Telephone indicators.** Abel. (Soc. Générale des Téléphones Réseaux Téléphoniques et Constructions Electriques.)

8958. **Applying electricity to the body.** Rigola.

9627. **Electric light fittings.** Faraday.

9864. **Electric switches.** Evered and Watson.

20816. **Connectors for electric conductors.** Keithley.

23881. **Heating metals electrically.** Thompson. (Coffin.)

24271. **Telephonic apparatus.** Bonnard and Piat.

24274. **Electrolytic decomposition of metallic salts.** Kellner.

1894.

666. **Holders for incandescent electric lamps.** Evans.

2007. **Electric switch.** Edison and Swan United Electric Light Company and Proctor.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	2⅜
— Pref.	—	2¼
Charing Cross and Strand	—	5
City of London	—	12¼
— Pref.	—	13½
Electric Construction	—	⅛
House-to-House	5	1½
India Rubber, Gutta Percha & Telegraph Co.	10	23½
Liverpool Electric Supply	5	6⅜
	4½	5½
London Electric Supply	5	1
Metropolitan Electric Supply	—	8⅜
National Telephone	5	4⅜
St. James', Pref.	—	8¼
Swan United	3½	3¼
Westminster Electric	—	6

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NOTES.

Telephony in Stuttgart.—A full night telephonic service is to be established here during the summer.

Carborandum in France.—Works are shortly to be erected in France for the manufacture of carborandum.

The Brussels Exhibition.—It has been decided not to hold the international exhibition at Brussels until 1896.

Society of Arts.—On Monday, at 8 p.m., the second Cantor lecture on "Photometry," by Captain W. De W. Abney, C.B., F.R.S., will be delivered.

Electric Tramway at Stuttgart.—The local authorities have approved of the introduction of electric traction on the tramway lines of Stuttgart.

Personal.—Mr. A. B. Blackburn, M.I.C.E. (late with Messrs. Mather and Platt, Limited), has been appointed chief engineer to the Electric Construction Company.

Private Bill Legislation.—The Charing Cross, Euston, and Hampstead Railway Bill will be dealt with by the Examiners on Standing Orders to-day (Friday).

Berlin.—The Berlin Electricity Works are making rapid progress with the laying of electric light cables in the new districts for which they have received powers.

Electric Tricycle.—The King of the Belgians, who met with a slight accident on Wednesday when riding a bicycle, is now having constructed a tricycle to be operated by electricity.

Lighting of Markets.—The Crawford Markets, in Calcutta, are to be lighted by electricity. The current will be supplied by a Silvertown dynamo driven by a 25-h.p. compound semi-fixed engine.

A Large Railway Contract.—An extensive contract has been made by the Nassau Electric Railroad Company of Brooklyn, N.Y., for the construction of 100 miles of street railway in Brooklyn and the country towns.

Electrical Exhibition at Leipzig.—In view of the second general meeting of the Union of German Electricians, which is to take place at Leipzig, an electrical exhibition is to be held there in the Crystal Palace from June 8 to 17.

Explosion at Nantes.—On Wednesday evening, according to a yesterday's telegram from Paris, an explosion of gas occurred in connection with the underground electric light mains at Nantes. Three persons were injured, one rather seriously.

Electric Traction at Hamburg.—The Hamburg electric tramway was formally opened on Friday. The line is worked on the Thomson-Houston system, and has been constructed by a Berlin company. There are 21¾ miles of line and 42 cars.

Cost of a Provisional Order.—The Bridgend Chamber of Trade have decided to obtain legal opinion on the action of the Local Board in charging the costs of a provisional order for the electric lighting of the town—amounting to over £200—on the current rate.

Not in a Hurry.—A French weekly electrical paper dated 1st inst. records that trials were made of the Heilmann electric locomotive on February 2. It is to be hoped that no dangerous results will ensue from the haste made by the staff to discover this item of "news."

Students of the Institution.—A students' meeting of the Institution of Electrical Engineers will be held this (Friday) evening at 28, Victoria-street, S.W. A paper will be read by Mr. A. F. Berry, entitled "Notes on Alternate-Current Transformers." Mr. W. M. Mordey will take the chair.

Charges for Current at Hull.—The Electric Lighting Committee of the Hull Corporation have decided to reduce the charge for the supply of electrical energy to consumers from 7d. to 6½d. per unit. The supply of current for motive-power purposes has been fixed at 5d. per unit.

Electrical Exhibition at Budapest.—The authorities of the Hungarian *Handels Museum* are arranging to hold from May 27 to September 30 next an electrical exhibition at Budapest. It main object is to show the various machines employed in small industries to which electromotors are applicable.

Telegraph Department.—Mr. A. Morley, replying in the House of Commons on Tuesday to a question by Mr. Macdonald, said the Departmental Committee upon the working of the Telegraph Department were now considering their report, and he had reason to believe that it would be in his hands in a few weeks.

Electric Tramway at Stockholm.—Portions of the electric tramway between Stockholm and Djursholm have been several times tested with satisfactory results on the whole, although some alterations in details have been found necessary. The line has not yet been officially taken over, but the installation is completed.

A Competition for Electricians.—The Swiss Association of Electricians have inaugurated a prize competition of £80 for the best critical paper on the regulations in connection with house installations and for the establishment of a scheme of normal specifications. Unfortunately, only Swiss electricians are allowed to compete.

Electric Lighting of Railway Carriages.—The Association of German Railway Managements has come to the conclusion that at present there has not been sufficient experience to enable a definite decision to be arrived at as to the efficiency and economy of electric lighting in railway passenger carriages. The public, however, has no doubt as to the efficiency.

Electric Railway for Vienna.—The Länder Bank and the Vienna Tramway Company are combining for the formation of a large Viennese transit undertaking, with a capital of from £2,000,000 to £3,000,000. This is required for the construction of an electric ring railway, and the present tramway company will be incorporated with the new concern.

Electromotors for Small Industries.—In the town of Esslingen the advantage of the use of electromotors in small industries is evidently appreciated. According to the *Elektrotechnische Zeitschrift*, 34 electromotors of a total of 133 h.p. are in use there. Of these 11 are used for metal-working, 10 for wood-working, three in graphic trades, three in chemical trades, two each by butchers and tanneries, and one each in dyeworks, ropeworks, and by a goldsmith.

Northern Society of Electrical Engineers.—A meeting of this society will take place on Monday next, the 9th inst., at the Palatine Hotel, Hunt's Bank, Manchester. The discussion will be continued on Mr. Rider's paper, entitled "Notes on Designing a System of Underground Electric Light Mains," and on Mr. Clirehugh's paper on "The Various Systems of Underground Mains and Methods of Laying Same." A paper will be read on "Electricity Meters," by Mr. R. P. Wilson.

Handling of Steel Billets by Electricity.—The transmission of power by electricity is now in operation at the works of the Illinois Steel Company, Joliet, Ill., for a variety of purposes. One application comprises an electrical apparatus employed to load steel billets on flat cars with the

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minimum amount of manual labour. Another recently introduced means of electrically using power at the same establishment is exemplified in two electro-hydraulic ingot charging machines used in the heating-room.

Oil and Petroleum Engines.—A paper on oil and petroleum engines was read before the South Staffordshire Iron and Steel Works' Managers on Saturday evening, at Dudley, by Mr. H. M. Waynforth, A.M.I.C.E. (demonstrator in engineering, Mason College). The author stated that much attention was now being given to the application of oil-engines for agricultural purposes, barge and launch propulsion, electric lighting, and pumping, and that the results obtained were said to be highly satisfactory.

Altrincham Electric Supply Company.—The Altrincham Electric Supply Company, Limited, the registration of which is announced in another column, is inviting subscriptions to an issue of 25,000 ordinary shares of £1 each. The Company has been formed to undertake the supply of the electric light in Altrincham, Bowdon, Dunham Massey, Hale, and adjoining districts. The offices are at Temple-chambers, Brazennose-street, Manchester, and the subscription list closes on or before Tuesday next, the 10th inst.

Telephony in Bohemia.—Arrangements have been made for the establishment during the present year in Bohemia of telephone systems in Beraun, Brandeis, Franzenbad, Friedland, Komotau, Kralup, Kreibitz, Lobositz, Marienbad, Melnik, Nixdorf, Raudnitz, Roztok, Schlau, Trautenau, and Weipert; and of interurban lines between Prague and Tetschen, *viâ* Roztok, Kralup, Melnik, Raudnitz, Leitmeritz, Lobositz, and Aussig; and between Brüx and Komotau, and between Reichenberg and Friedland.

Oullins.—Work in connection with the electric tramway at Oullins, near Lyons, is being actively pushed forward, workmen being employed night and day in laying the rails and fixing the posts for the conductors. There are to be eight self-contained cars, each carrying 40 passengers. These are being furnished by the Compagnie Française du Matérial de Chemin de Fer. Each car has two electromotors of a combined power of 35 h.p. Lighting will be effected by three internal and two external incandescent lamps.

Ulm.—The local authorities have decided to build an electric supply station which is not only to furnish current for lighting purposes, but also for an electric tramway. The work will be carried out by Messrs. Schuckert and Co., of Nuremberg. The company will receive a 50 years' concession from the town, paying over to it a certain percentage of the receipts. The town may, however, take over the works at the expiration of 10 years, or at subsequent periods of five years, on paying various sums of money which have been set down in the contract.

Lecture.—A lecture on the subject of electrical forging and welding was delivered on Saturday evening before the Sheffield Society of Engineers by Mr. T. Scott Anderson, A.M.I.E.E. Samples of welding, forging, hardening, and tempering were exhibited, and the lecturer closed with the remark that what was necessary now was for the manufacturer to make known his difficulties in accomplishing certain work, and there was little fear that electricity would help him over those difficulties, and that sooner or later it must take an important place in all our industries.

The Theatrophone and the Volunteers.—Amongst the amusements provided at Canterbury during the recent visit of the volunteers was an entertainment by means of the telephone, which had just been completed between London and that city. The National Telephone Company took the opportunity of experimenting with the wires by connecting the London music halls with the premises of Councillor Lukey, the mayor, and some of the leading citizens. Besides this a large number of volunteers took advantage of the opportunity.

Stirling.—The Stirling Town Council, which some days ago resolved by a majority not to oppose the application of the Caledonian Electric Supply Company for a provisional order, have had the matter again before them at a special meeting. On the recommendation of the Electric Lighting Committee, they resolved to decline to withdraw their opposition to the order of the company, and decided to request the Board of Trade to withhold their consent to the order on the ground that the company now refuse to grant to the Council the terms they had previously offered.

Commercial Exhibition in South Africa.—A permanent exhibition in South Africa of samples and specimens of British goods and manufactures is being organised by Messrs. Hannan and Co., of 144, Leadenhall-street, E.C. It is proposed to make the exhibition a permanently active centre for the furtherance of British trade and trading interests, to gather together a collection of British machinery and commodities of a widely varied character, and bring the same immediately to the notice of buyers generally. The headquarters of the exhibition will be at Johannesburg.

Universal Index to Technical and Scientific Literature.—A weekly publication, entitled the "Universal Index to the World's Technical and Scientific Literature," is about to be issued. It will contain a classified list of all technical and scientific periodicals, arranged according to the places where they are published, the terms of subscription, and a full list of their contents, and a list of books and other publications dealing with the same subject. At the end of the year an index of subjects and authors will be added to each part. Communications may be addressed to the editor of the "Index," at Lenaugasse 5, Vienna (VIII.).

Electric Towing on Canals.—A permit for 50 years has been granted to the Cataract General Electric Company authorising it to enter upon all canal lands of the state for the purpose of constructing either on or over or under either canal bank a system for propelling canal boats by electricity, without interference with the present method of operation. The company must have its plant for operating boats by electricity in operation on the Erie Canal between Buffalo and Albany within three years from date. The company will obtain its power at Niagara Falls, from the Niagara Power Company, and transmit it to Albany along the line of the Erie Canal.

Central London Railway.—The Standing Orders Committee of the House of Commons met on Tuesday to consider a report from the examiners to the effect that the Central London Railway Company had failed to comply with the standing orders in respect of their petition for leave to introduce a Bill to extend the time within which to construct this railway. The proceedings of the committee were conducted in private, but it was announced that the committee had decided to dispense with the standing orders not complied with. In the event of this Bill being sanctioned, the time for completing this line will be extended until June 28, 1900.

The Institution.—A meeting of the Institution of Electrical Engineers will be held on Thursday next, the 12th inst. The paper read at the previous assembly, on "The Best Resistance for the Receiving Instrument with a Leaky Telegraph Line," by Prof. W. E. Ayrton, F.R.S., past-president, and Mr. C. S. Whitehead, M.A., will be

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discussed. Papers on the following will be read: "Transparent Conducting Screens for Electric and other Apparatus," and on "An Astatic Station Voltmeter," both by Prof. W. E. Ayrton, F.R.S., and Mr. T. Mather. A paper on the "Cost of Electrical Energy," by Mr. R. E. Crompton, M.I.C.E., will also be presented.

Institution of Engineers and Shipbuilders.—The seventh general meeting of the North-East Coast Institution of Engineers and Shipbuilders will be held on Wednesday next in the lecture hall of the Subscription Literary Society, Fawcett-street, Sunderland. After the transaction of formal business, Mr. William Bell will reply to the discussion on his paper "On a New System of Construction for Large Vessels of Cellular Type." A discussion will take place on Mr. William Stafford's paper on "Oil-engines," and a paper on "Basis for Classification of Vessels Proportioned to their Strength to Resist Bending and Vibration," by Mr. Arthur R. Liddell, will be read.

Fiume.—According to *L'Elettricista*, an important electric power transmission plant has been erected, and is at work, near Fiume. The water power is obtained from the Burrida, the hydraulic installation having been supplied by the firm of Alberto Riva, of Milan. The total power obtained is 450 h.p., and there are three generators each of 150 h.p., and three electromotors of the same size. Messrs. Brown, Boveri, and Co. have furnished the electrical plant. The dynamos are of the Brown type, and furnish current at 3,000 volts. The power is transmitted to the cotton mills of Messrs. Amman and Co., one of which is at Pordenone, 2½ miles from the generating station, and the other is at Fiume, six miles distant.

Friday's Aurora and the Telegraph Wires.—Mr. W. H. Preece has written to the *Times* as follows: "There was an extremely brilliant display of aurora between 10 and 10.45 p.m. on Friday, the 30th ult. It was accompanied, as usual, by very strong earth currents on all telegraph lines. But at 10.20 p.m., when all the telegraph circuits were idle, a peculiar frizzling and bubbling noise was heard upon a telephone inserted upon a long Irish wire at Llanfairpwll in Anglesey. At 2 a.m. on Saturday, the 31st ult., 'twangs' were heard, as if a stretched wire had been struck. These were followed by a kind of whistling sound. Were these signals from space, or mere disturbances of atmospheric electricity?"

The Kingswood Electric Tramway.—Considerable surprise is being expressed at St. George and Kingswood at the unexpected opposition to the electric tramway, of which notice has been given by two local firms. It is difficult to understand on what ground the opposition is based, seeing that there is an available space of 9ft. 6in. between the kerb and the tramway lines in West-street. The local committees will be at once called together, and the strongest evidence will be obtained in favour of the scheme. The company had given instructions for the preparation of the plans and specifications, and it was intended to proceed with the work as soon as possible after the Royal assent had been obtained to the Bill.

Electrolytic Thermo-electric Cells.—Mr. A. Gockel[1] in the *Ann. Phys. Chem.*, has investigated the E.M.F. of thermo-elements constructed on the following plan:

$$\frac{\text{Hg} \mid \text{solid Hg salt} : \text{salt solution} : \text{solid Hg salt} \mid \text{Hg}}{\text{cold} \qquad\qquad \text{hot}}$$

He finds that, in general, the thermo-electric force for 1deg. difference of temperature increases with dilution of the solution, and that in equivalent dilute solutions of similar salts of an acid it is practically the same. He confirms, in general, Ebeling's observation, that the worst conductors are thermo-electrically the most active, and that some show a maximum thermo-electric force at the concentration of maximum conductivity.

American Institute of Electrical Engineers.—We have received a copy of volume x. of the *Transactions* of this institution, containing reports of the papers and discussions of the past year. Among the papers which are contained in the volume are—"Electrical Recording Meters," by Mr. C. D. Haskins; "The Most Economical Age of Incandescent Lamps," by Mr. Carl Hering; "Impedance," by Mr. A. E. Kennelly; "A New Method for the Control of Electrical Energy," by Mr. D. McF. Moore; and "Practicability of Electric Conduit Railways," by Mr. Albert Stetson. Obituary notices on Dr. Norvin Green, Mr. George B Prescott, jun., and Mr. Anthony Reckenzaun are given. The volume, which comprises over 700 pages, has as a frontispiece a portrait of Mr. Alexander Graham Bell, the seventh president of the institute. The book is published by the institute at 12, West Thirty-first-street, New York.

Tramways Institute of Great Britain and Ireland.—The next council and committee meeting of the Tramways Institute will take place at the Albion Hotel, Manchester, on Thursday next, the 12th inst. The executive committee will assemble at 10 a.m., and the general council at 11 a.m. Gentlemen who intend being present will oblige if they will signify their intention as early as possible to the secretary, Mr. J. G. B. Elliott, 18, Eldon-street, E.C. The following is the agenda: Report of committee on the Board of Trade's regulations for electric traction; discussion on Mr. Schwann's Bill to enable local authorities to work tramways; paper on "Mechanical Tramway Electric Traction," by M. Victor Popp, of Paris; paper on "The Heating of Railway and Tramway Carriages," by Mr. Frank Mellersh; and a paper on "Vereker and Yeats's Car Starter," by Mr. H. L. Furlonge. On the following day visits will be paid to the Manchester tramways and to the Manchester Ship Canal.

Change of Conductivity of a Solution by the Addition of a Non-electrolyte.—Mr. R. J. Holland, in the *Ann. Phys. Chem.*, gives the following account of his general results. The electrical conductivity of a solution of an electrolyte in methylic alcohol diminishes on the addition of a non-conductor, the diminution varying with the nature of the non-electrolyte and with the degree of dilution. The four non-electrolytes benzene, toluene, xylene, and oil turpentine diminish the conductivity in the order given. The diminution varies for each volume per cent. of non-electrolyte added from 1·7 to 2 per cent. of the conductivity of the corresponding normal solution for 0·01-normal solutions; 1·6–1·75 per cent. for 0·001-normal, and 1·4–1·6 per cent. for 0·0005-normal. The temperature coefficients of alcoholic solutions increase with increasing dilution; are only half as great as in the case of aqueous solutions; and are very little affected by the addition of a non-conductor. The conductivity of methylic alcohol solutions up to a concentration of 20 per cent. of non-electrolyte is very exactly represented by Arrhenius's formula. No connection between electrical conductivity and fluid friction was evident.

The Johnstone System of Conduits.—An illustrated pamphlet descriptive of the Johnstone system of conduits has just been issued by the International Electric Subway Company, Limited, of 39, Victoria street, Westminster, S.W. This system of conduits, which was described in this journal some time ago, has been largely adopted in the United States, and particularly in New York, Chicago, and Philadelphia. It has also obtained

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a firm footing in this country. The Portsmouth Town Council in the latter half of 1893 accepted the company's tender for the whole of the underground mains in connection with the municipal central electric light station. In this case a complete system, extending through upwards of eight miles of streets, including the Johnstone conduit, drawing-in and junction boxes, indiarubber-insulated cables, and an extensive arc lighting circuit, has been put down, in the construction of which several new and specially-designed features have been introduced for the first time. The whole of the work has been carried out very successfully. In addition to this undertaking, the Johnstone conduit has also been laid by the City of London Electric Light Company and by the Keswick Electric Light Company. The pamphlet contains a list of Press opinions and testimonials, and illustrations of the system as carried out at Portsmouth.

Tables and Formulæ for Electric Railway Engineers.—The W. J. Johnston Company, Limited, of 253, Broadway, New York, have forwarded us a copy of a "Reference Book of Tables and Formulas for Electric Street Railway Engineers," by Mr. E. A. Merrill, author of "Electric Lighting Specifications." The object of this book is to meet a practical need by collecting and arranging in a concise, logical order those tables and formulæ which are constantly used by the electric street railway engineer in making estimates, ordering material, on construction work, etc. All superfluous examples and explanations have been excluded, as well as unnecessary extensions of formulæ into tables when such extensions consist only in the simplest arithmetical processes; every element thus stands out in clean-cut, terse form. To facilitate reference without the use of the index, all matter follows a logical order, beginning with the details of the steam plant, and then taking up successively cars and their equipment, overhead work, track work, and miscellaneous tables and formulæ in constant use but only indirectly related to the main division. Considerable care has been taken not only in selecting and checking material compiled directly, but several original tables and formulæ have been added, especially in the sections on calculations. Moreover, many tables and formulæ have been extended and modified so as to meet the conditions imposed by street railway work.

The Reading Electric Supply Company.—Subscriptions to shares are being invited by the Reading Electric Supply Company, Limited, which was incorporated in January, 1892, for the purposes of supplying electricity and electrical energy. The Company has been in negotiation with the Corporation with a view to obtaining the consent of the Corporation to the grant of a provisional order by the Board of Trade giving the Company the right of supplying electricity throughout the whole of the borough, and the terms of this provisional order having been settled between the Company and the Corporation, the Board of Trade has granted the order, which has been confirmed by Act of Parliament. The Company will acquire as a going concern the electric lighting installation and the business which was established in the borough of Reading in 1889 by the Laing, Wharton, and Down Construction Syndicate, Limited, and which has since been carried on by that syndicate under the style of the Reading Electric Light Depôt, together with the freehold land, and the buildings, machinery, plant, etc. The Company is also in negotiation with the Corporation for the acquisition of an alternative site in Mill-lane, which from its central situation and proximity to the River Kennet also offers an advantageous position for the erection of a new and permanent central supply station. The subscription list is now open, and will close on Tuesday, the 17th inst. The capital is £75,000, in 15,000 shares of £5 each, and the present issue comprises £45,000 in 9,000 shares.

The Permeability of Oxygen.—Mr. R. Hennig, in the columns of a German contemporary, gives an account of a new determination of the relative permeability of oxygen and atmospheric air by Toepler's method, the principle of which is as follows: A glass tube of small internal diameter has a slight bend in it, and is placed symmetrically in a magnetic field, the bend being downwards and filled with a short thread of some liquid, the arms on either side being filled with the gases whose permeability is to be compared. If one gas is more permeable than the other, it is attracted with greater force into the magnetic field, and this action is balanced by the force of gravity against which the thread of liquid has to be raised. Any want of uniformity in the field can be detected by filling both limbs with the same gas and observing the deflection, and formulæ are worked out for the difference in permeability, with this correction. Methods of measurement of the field are discussed, and Weber's bifilar method is preferred, owing to the small size of the requisite apparatus and the long range of the values which may be accurately determined. The mean error of the author's observations is about 3½ per cent., and the probable error is 1 per cent. The following table gives the author's result compared with other observers:

Observer.	Temperature. Deg.	Pressure. Atm.	$(\mu_1 - \mu_2) \times 10^6$, reduced to 1 Atm.
Quincke ...	16	1–8	0·097
...	.....	40	0·125
Du Bois ...	15	1	0·093
Curie ...	20	5–20	0·121
Hennig ...	25	1–4	0·096

French Electric Coast Lights.—Some important developments in the matter of electric lights for lighthouses in France have recently been made public, and it has been with a view of obtaining full information respecting *les feux éclairs*, or "lightning lights," that a committee from the Trinity House went over to inspect the lighthouse of La Heve, on the extreme point of the northern bank of the estuary of the Seine, from which a light of the new type had been shown for some months. It was also desired to observe the system of gas-lighted buoys, by means of which the French authorities hope to avoid the necessity of maintaining costly lightships in certain positions. The committee consisted of Captain G. R. Vyvyan, Admiral Sir Leopold M'Clintock, and Captain Slader, elder brethren of the Trinity House, who were accompanied by Mr. Charles A. Kent, the secretary, and Mr. Thomas Matthews, the engineer to the Corporation. At Havre the committee were met by M. Bourdelles, the inspector-general, M. Guiraud, engineer for the Seine district, MM. Ribiére and Vetillart, also engineers of the Lighthouse Department of the Ministry of Public Works, and by them were received with great courtesy. The party visited the lighthouse at La Heve, where the whole of the system was fully explained in detail, the quick flashes of the light being shown to be produced by rapid rotation of the lenses. The committee were afterwards entertained at luncheon, at which the greatest good feeling prevailed, and an earnest desire was expressed on the part of the lighthouse authorities of both countries to co-operate in every possible way in the great work of adding to the safety of sea-voyaging by means of lighthouses and other aids to navigation. The committee subsequently, when crossing the Channel, made some comparisons of the quick flashes of La Heve lights with the slower characteristics of the St. Catherine's electric light, but the results of their observations are not yet made known.

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Electric Illumination.—The afternoon lectures at the Royal Institution were resumed on Tuesday, and the first lecture of a course of four on "Electric Illumination" was delivered by Dr. J. A. Fleming, F.R.S. The lecturer began by giving a brief sketch of the progress of electric lighting in the United Kingdom since the Board of Trade enquiry in 1889. There are now about 700,000 incandescence electric lamps in use in London, and about 425,000 in the provinces. The electric supply of the Metropolis is furnished by 13 companies or corporations, and about 60 or 70 towns in the United Kingdom have also a public electric supply. The total length of electric underground mains now laid is about 700 miles. This progress is chiefly the work of the last five years. The lecturer then proceeded to a series of experimental demonstrations intended to illustrate the laws of the propagation of electric currents and the methods by which the energy of a current is converted into heat and light. The light from electric incandescent lamps and arc lamps was next analysed by the prism, and the different qualities of the light emitted by sources at various temperatures examined. It was shown that at the higher temperatures the light was relatively richer in violet rays. Numerous experiments were also shown to illustrate the methods of photometric comparison of lights of different intensities and qualities, and the difficulty of comparison when the lights are at very different temperatures pointed out. For want of a better standard the standard candle is still preserved as a unit of light. The illumination produced by a standard candle at a distance of 1ft. on a white surface is called one candle-foot. This is the least illumination for comfortable reading. Bright moonlight is about one-fiftieth of a candle-foot, whilst diffuse daylight may be 20 to 40 candle-feet. The comparison of the illumination on two surfaces when these differ, not only in brightness or luminosity but in colour, was next discussed, and explanations given of the processes adopted for such photometric comparisons. The remaining lectures of this course will be given on the 10th, 17th, and 24th inst., and will be occupied with the discussion of the methods of electric illumination by arc and incandescence lamps, and descriptions of electric generating stations.

The International Electric Storage, Limited.—As will be seen by our advertisement columns, the International Electric Storage, Limited, has been formed with a capital of £200,000, divided into 40,000 shares of £5 each, of which 9,000 will be allotted to the vendors and patentees. Subscriptions are now invited for the first issue of shares to the extent of £150,000. The Company has been formed to purchase and work the British rights of the invention of Messrs. Theryc and Oblasser for electric accumulators, and it has also acquired the right for 18 months to purchase the patents which have already been obtained in some and applied for in other countries. The directors of the Paris, Lyons, and Mediterranean Railway Company have for over 15 months been making private experiments with the battery. They appointed a commission to report on the battery, and the commission reported in its favour, and have now nearly completed a locomotive to produce nominally 700 h.p., with ability to reach 1,100 h.p. They propose running at a constant speed of about 67½ miles per hour on the level and about 50 miles an hour on gradients. It is expected that the journey from Paris to Nice will be accomplished in 12 hours with this new type of locomotive operated by these accumulators. The Company intends to at once take steps to practically demonstrate the utility of the battery for locomotion on railways, tramway and vehicular traction, the propulsion of boats, for naval and military purposes, traction in mining operations, and for lighting purposes. One of the mail coaches carrying parcels, etc., between London and Chatham, and elsewhere, has been fitted with the Theryc-Oblasser battery, and it has travelled between London and Chatham since March 2, the light giving complete satisfaction. Negotiations with the London Road-Car Company for lighting their vehicles have been nearly completed, and negotiations have been opened with the London General Omnibus Company for a similar purpose. Several of the associated proprietors of omnibuses, as also certain tramway companies, are being arranged with for lighting their vehicles. The price to be paid for the purchase of the British patent, and for the right to purchase the foreign and colonial patents, is £40,000 in cash and 8,000 fully-paid shares. The subscription list was opened yesterday, and will close on or before to-morrow (Saturday) for London and on Monday for the country.

Report on the Hermite System at Worthing.—A report on the results of the trial of M. Hermite's system of treating sewage with electrolysed sea-water has been prepared by Dr. C. Kelly, medical officer of health for the borough. The report contains the results of chemical and bacteriological analyses made respectively by Dr. Dupré, of Westminster, and Dr. Klein, of St. Bartholomew's Hospital. Dr. Kelly says he has not gone into the question of cost, but he points out that besides the annual cost of producing sufficient electrolysed fluid there would be a very great outlay in putting down a fresh set of mains, pipes, and cisterns, so as to convey it to each house. The results of the various tests are set out in detail, and Dr. Kelly concludes: "Since there is no instantaneous decomposition of fæcal matter and no sterilisation of sewage, I am of opinion that the process, as far as the late trials have gone, has therefore failed to produce the results which are claimed for it by its inventor." Concerning this report the Town Council have received a letter, read at an assembly of that body on Tuesday, from Mr. Cooper, of Messrs. Paterson and Cooper, the English agents for M. Hermite. Commenting upon Dr. Kelly's unfavourable report of his experiments at Worthing, Mr. Cooper says Dr. Kelly's conclusions are so utterly opposed to the results found by many of the most eminent experts that he can only think there must be some mistake in taking the samples; at any rate, it appeared to be a very rash proceeding to report upon a process of that sort from a single sample such as appeared to have been submitted to Drs. Dupré and Klein. The letter states: "I am bound to protest against this report. The conclusions arrived at are erroneous, and calculated to give an entirely wrong impression, and I make the statement that when the process is properly investigated the conclusions arrived at will be absolutely opposed to those of Dr. Kelly. There are numerous men of high standing now engaged upon investigating this process, and whose reports we may hope to get shortly. I may quote from the report of Dr. Alain Riton, professor at the Naval Hospital, Brest, and an old student of the Pasteur Institute: 'The experiments that I have made lead me to the conclusion that electrolysed sea-water is a perfect deodorant and an excellent antiseptic, which rapidly destroys the most hardy micro-organisms.' I venture to request that this report of Dr. Kelly's may not be adopted, and that we may be allowed to answer it in detail." Councillor Dr. Goldsmith supported the view that a mistake had been made in taking samples, and said he had been assured by Dr. Ruffer that the solution absolutely killed all microbes. The Council will take no further action until the receipt of the reports promised by Sir Henry Roscoe and Dr. Ruffer.

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THE COATBRIDGE CENTRAL ELECTRIC LIGHT STATION.

The Opening of the Works.

By invitation of the directors of the Scottish House-to-House Electricity Company, Limited, a large company assembled on Saturday afternoon at their works in Dundyvan-road, Coatbridge, to witness the opening of the works by Lord Kelvin.. Among those present were the following: Major-General Webber, C.B.; Mr. Timothy Bost, chairman; Mr. Angus Macleod, managing director; Dr. James Colquohoun, LL.D.; Mr. Wm. D. Cairney, C.A.; Mr. John Hannay, Mr. Wm. A. Bryson, M.I.E.E., F.R.S.E.; Prof. Andrew Jamieson, M.I.C.E.; Mr. W. M. Mordey, M.I.E.E.; Mr. W. Geipel, M.I.E.E.; Mr. Francis Teague, M.I.E.E.; Mr. Magnus Maclean, F.R.S.E.; Mr. A. Meikle, M.I.E.E.; Mr. John Kerr, M.I.M.E.; Mr. J. W. Hartley, Sheriff Mair, Mr. John M. Alston, town clerk, Coatbridge; the town clerk of Ayr; Mr. Alex. M'G. Mitchell, Mr. S. Gemmil, town chamberlain, Coatbridge; Bailie Sharp, Bailie Davidson, Bailie Bird, the chairman of the Coatbridge Gas Company; Bailie Wilson, Bailie Chisholm, Bailie Lavell, Bailie Paton, Glasgow; Councillor Angus Campbell, Glasgow; Councillor Don. Hamilton, Glasgow; Councillor Hugh Mayberry, Glasgow; Mr. John Munro, M.I.E.E.; Mr. John Mayer, F.C.S.; Mr. Elsdon Dew, Mr. T. C. Crichton Fulton, Mr. J. I. Hall, Edinburgh; the Rev. Mr. Ireland, the parish minister; and representative ministers of other denominations. The gas generators were first inspected, then one of the gas-engines was started, and Lord Kelvin formally turned on the light at a switchboard in the test-room. Cake and wine were afterwards served, and in reply to the toast of his health, proposed by the chairman of the company (Mr. Timothy Bost), Lord Kelvin said it had been a very great pleasure to him to see what he had seen that day in connection with these works. There had been a great increase in the consumption of electricity, and the case of Coatbridge, he thought, should be an example for the rest of the world to follow. The system which had been adopted there had been tried, and found successful, and in bringing it to Coatbridge he thought the company's judgment had been justified by considering that Coatbridge was a centre which might be available for a supply to other places which had no central station. There were public works not only in Coatbridge, but at distances of two, three, and four miles, which they might look forward to as being supplied with the electric light from the station which they had inaugurated that day. But there was another part of the system which they had seen opened that day, and which, without using too large a word, might be found to have an interest to the whole civilised world. The unique feature of the station was the use of gas-engines. They must not say yet what the results would be, but he thought they had all seen enough to form the most sanguine expectations.

Dr. Colquhoun proposed "The Health of the Provost, Magistrates, and Town Council of Coatbridge," which was acknowledged by Bailie Chisholm. Prof. Jamieson proposed "The Scottish House-to-House Electricity Company," for which Mr. A. M'Leod, managing director, replied. The company afterwards inspected the works.

The System Adopted.

Acting on the advice of their consulting engineer, Mr. Wm. A. Bryson, M.I.E.E., F.R.S.E., the Scottish House-to-House Company decided to depart from the beaten track of central lighting station design, and adopted the novel improvement of utilising the most modern type of gas-engines as the motive power, using carbon-monoxide in lieu of steam, thus avoiding costly foundations, chimney stack, and expensive working staff.

The current is distributed to the various customers on the low-tension alternating system, the mains being fed from transformers fixed in underground chambers placed in convenient parts of the town. The transformers are operated by high-tension feeders, which run from the generating station. The alternators are driven by gas-engines entirely, while the gas is made in producers on the site.

The Station Buildings.

The offices comprise a general office, waiting-room, board-room, engineer's office, testing-room and stores, the floors of which are raised above the level of the works, the engineer's office being so situated that the engineer can command a general supervision of the whole of the engine and dynamo room. Passing through the offices, we come into the engine and dynamo room, which is 53ft. long by 38ft. wide, and while only of sufficient size for the accommodation of the present plant, it is so arranged that the end wall may be easily removed for extensions. The room is lined with whit eglazed bricks. The floor is made of granolithic cement of warm red colour, which gives to it a neat and comfortable appearance. For convenience in operating the machinery there is fixed a very useful and handy five-ton travelling crane by Messrs. Carrick and Ritchie, of Edinburgh. Between the dynamo-room and railway siding is the producer-house, so arranged that fuel may be unloaded direct from the truck on to the charging platform, while the producers are placed in a pit so that the hoppers are at a convenient level; thus the minimum amount of labour is required for passing the coal from the truck into the producer. The buildings have been designed by and erected under the supervision of Mr. Alex. M. E. Mitchell, architect, of Coatbridge.

The Gas-Generating Plant.

There are two gas producers, each capable of generating gas for 120 b.h.p., and they are fitted with Hartley's improved apparatus for removing clinkers. Each producer has an independent set of cooling and cleaning apparatus, consisting of atmospheric cooler, hydraulic box for arresting the passage of dust, etc., coke and sawdust scrubbers, with valve and connection to the gasholder. There are two small steam-boilers for supplying the small quantity of steam required for making the gas, together with steam for starting the gas-engines. The gasholder is 15ft. in diameter by 10ft. deep, and works in a brick tank constructed in the ground adjoining the producer-house.

The Gas-engines.

The gas-engines are of the double-acting type, with an Otto cycle. Each engine has two cylinders placed side by side, and runs at a speed of 180 revolutions per minute, at which speed they are to develop up to 120 i.h.p. A high-speed sensitive governor of the Buss type controls the supply of gas and air, the quantities of which are varied to suit the load down to one-third of full power, below which the governor cuts off a certain number of explosions in the usual way. For starting the engines steam is used. It is admitted by a valve operated by a hand-lever, which the attendant opens and closes, in the same way as a slide-valve is worked by an ordinary eccentric. To ensure steadiness, each pair of engines is fitted with three fly-wheels, so that there is one on either side of each crank. The middle flywheel is grooved for rope driving. For circulating the cooling-water, which is contained in a large tank outside the engine-room, there is used a small centrifugal pump, driven by an alternate-current motor. This motor is operated from the low-tension mains which serve for lighting the station, and is at once an interesting and positive assurance of the suitability of the alternate current for power distribution. A "stand-by" connection has been made with the water company's mains in case of mishap to the pump. The whole of the gas plant and gas-engines have been made by Messrs. Dick, Kerr, and Co., of Kilmarnock, and were put in their places under the superintendence of the manager, Mr. J. W. Hartley.

The Alternators.

The alternators are of the Mordey-Victoria type. Each generates 50 kilowatts at 2,000 volts pressure, the speed being 600 revolutions per minute. The pulleys are 24in. in diameter, with grooves for eight ropes 1in. in diameter. The speed of the ropes is consequently 63ft. per second (43 miles an hour), and the net strain is equivalent to about 100lb. weight per square inch of rope. With a view to ascertaining the most suitable class of rope, one of the alternators is driven by cotton, the others by manilla ropes. The alternators are set in sliding beds, built in flush with the floor, which gives a neat appearance to the machines.

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Amongst the chief features of the alternators are the stationary armature, any coil of which can be replaced in a few minutes; heavy revolving pole-pieces excited by a single coil concentric with the shaft, thus giving great steadiness of motion and freedom from wear and tear of coils; perfect parallel working at all loads and of all sizes. This has been demonstrated by the parallel working of these alternators at Coatbridge, which are the first alternators which have been so run with gas-engines. This success is doubtless largely due to the steadying momentum of the heavy revolving mass in the poles of the alternators. It is also claimed that the alternators have an unusually high efficiency at all loads. The power of being able to run in parallel has a most important bearing on the all-year-round economy of working, as it is never necessary to run more plant than corresponds with the total load, as is so frequently the case when running alternators on separate circuits, and when the engines would be frequently working under their full power, and consequently with a falling off in efficiency. The output of the three alternators is 150 kilowatts, or 5,000 lamps of 8 c.p. each. Two Victoria dynamos are used as exciters, either of which is capable of exciting all three alternators at one time. They are driven by belts off the shafts of two of the alternators.

The Alternator Switchboards.

Opposite each alternator there is placed an alternator switchboard, on which is provided all the necessary switches and cut-outs, both for the primary as well as for the exciting circuit. The switch for the exciting current is provided with a carbon break. The primary switches are closed and opened by cords, and thus all danger of the operators touching high-tension parts is avoided. On each board is also provided ammeters for both primary and exciting circuits, together with a voltmeter and voltmeter transformer for indicating the primary voltage. There are, in addition, a pair of sockets for connecting the alternators to the synchronising wire. Each alternator board is connected to an omnibus conductor, through which the current passes to the instruments for measuring and recording the total output of the station. For convenience, these main instruments (main ammeter, registering ammeter, and registering voltmeter) are placed on a shelf on the synchroniser board. Under the shelf are placed the synchronisers, while above these are switches for cutting out the main instruments, as well as for closing the synchroniser circuit. On the top of the board are two lamps, which are used in the ordinary way for synchronising. All these boards are so arranged as to make future extension as simple as possible.

The Distributing Mains.

The high-pressure feeders consist of separate stranded conductors, insulated heavily with pure and vulcanised indiarubber, protected with braiding, and drawn into 3in. and 2in. cast-iron pipes. A spare cast-iron pipe has been laid in the ground along the route in order to provide for easy extension, and, in addition, there is laid a 1in. wrought-iron pipe for receiving special arc lighting mains. It will be an easy matter to withdraw any length and substitute a larger cable when occasion requires without breaking up the road. The low-pressure distributing mains consist of stranded cables having seven-eighths or one-tenth square inch section, insulated with vulcanised bitumen and laid in cast-iron troughs, which are then run in solid with bitumen and covered with a cast-iron cover plate. There are at present three transformer sub-stations. They consist of underground chambers about 5ft. square by 6ft. deep, constructed under the pavements at convenient points in the line of the mains. Each chamber is substantially constructed, and is connected with the main drain, so that no water may accumulate, and ample provision has been made for ventilation. The entrance is by a manhole in the pavement about 2ft. square; this is closed by the usual street-box cover. In each chamber there are two 18-kilowatt transformers, which are capable of supplying 1,200 8-c.p. lamps at one time. These are of the Mordey-Victoria type, each being closed in a watertight cast-iron case, and having double-pole primary fuses and switches in the top of the case. The connections to the primary mains are made through cast-iron boxes containing isolating switches, while the secondary mains are connected to omnibus bars, and thence to the transformers through switches and fuses specially designed by the Brush Electrical Engineering Company for this purpose, with Raworth's patent contacts. Either transformer may be switched off the low-tension omnibus bars, leaving the other to supply current, and it will thus be seen that the arrangements permit of complete isolation of any transformer without affecting the supply.

The extension of the distributing plant is easily accomplished without increasing or interfering with the low-tension mains and house-service connections; for whenever the demand exceeds the capacity of the main, it is merely necessary to construct an additional transformer-chamber, which has at once the effect of doubling the capacity of the low-tension mains at that point, while the high-tension mains already have spare carrying capacity and provision for drawing in another high-tension feeder. Thus there is provided every facility for extension without again breaking up the streets, so far as concerns those thoroughfares in which the mains are already laid.

The supervision of the work has been in the able hands of the company's resident engineer, Mr. Francis Teague, M.I.E.E., while the construction of the electrical portion of the work has been carried out under the supervision of Mr. W. Geipel, M.I.E.E., the capable superintending engineer of the Brush Electrical Engineering Company.

THE BEST RESISTANCE FOR THE RECEIVING INSTRUMENT ON A LEAKY TELEGRAPH LINE.*

BY PROF. W. E. AYRTON, F.R.S., PAST-PRESIDENT, AND C. S. WHITEHEAD, M.A.

1. If there be a single earth fault at any one point of an otherwise good telegraph line, P Q, Fig. 1, it is easy to

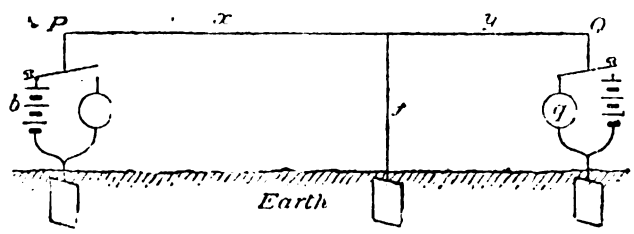

Fig. 1.

prove that the best resistance to give to the receiving instrument at either end of the line is equal to the apparent resistance of the line tested from that end when put to earth at the other end through a resistance equal to that of the signalling battery at that end. For example, if we desire to know what shall be the value of q, the resistance of the receiving instrument at the Q end, the line must be tested from the Q end, Fig. 2, when put to earth at the P end through a resistance, b, equal to that of the signalling battery usually employed at that end.

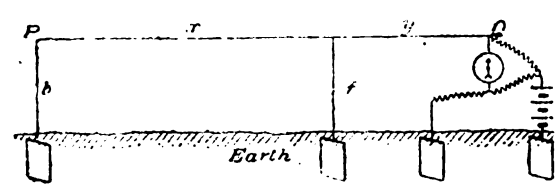

Fig. 2.

For if E be the E.M.F. of the signalling battery at the P end, f the resistance of the single earth fault, and x and y the resistances of the two portions of the line, the current, A, that flows through the receiving instrument at Q, Fig. 1, equals

$$\frac{f}{f+y+q} \times \frac{E}{b+x+\frac{f(y+q)}{f+y+q}}.$$

And the magnetic effect produced by an electromagnet of given size, shape, and construction is proportional to the product of the current into the square root of the resistance

* Paper read before the Institution of Electrical Engineers.

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of the wire with which the coil is wound. Therefore it follows that the magnetic effect of the receiving instrument at Q is proportional to A $\sqrt{q}$—that is, to

$$\frac{f\,E\sqrt{q}}{(f+y+q)(b+x)+f(y+q)};$$

and this has a maximum when

$$q=y+\frac{f(x+b)}{f+x+b},$$

that is, when q is equal to the apparent resistance of the line tested from the Q end and put to earth at the P end through a resistance, b.

2. During the course of some lectures at the Guilds Central Technical College last year on faults on telegraph lines, the question arose whether the above result was universally true for a distributed leak all along the line, or only for a single earth fault; and if this solution were not generally true, then what was the best resistance to give to the receiving instrument at the end of a telegraph line the leakage along which followed any law. The following is the complete solution of this question:

Let x be the resistance of the line up to any point measured from the sending or signalling end, P, and let $F(x)$ be the insulation resistance of a length of wire at that point having one ohm conductor resistance. When a signal is sent, let V be the P.D. set up between the line and the earth at the sending end, Fig. 3, and v the

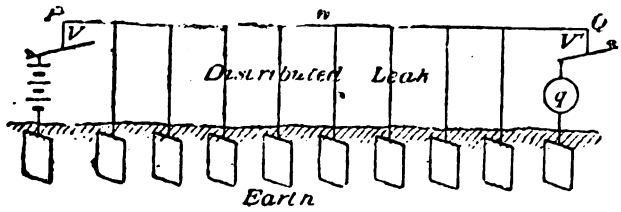

FIG. 3.

potential of the line at any point x; then v is given by the equation,

$$\frac{d^2v}{dx^2}=\frac{v}{F(x)} \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

If $F(x)$ be some simple known function of x, it may be possible to integrate this equation, and in that case we may proceed by performing the integration. For example, if $F(x)$ be a constant, t—that is, if the line be uniformly leaky—then, integrating, and introducing the terminal conditions, it may be shown that

$$v=V\frac{(\sqrt{t}-q)\epsilon^{\frac{x-w}{\sqrt{t}}}-(\sqrt{t}+q)\epsilon^{\frac{w-x}{\sqrt{t}}}}{(\sqrt{t}-q)\epsilon^{-\frac{w}{\sqrt{t}}}-(\sqrt{t}+q)\epsilon^{\frac{w}{\sqrt{t}}}} \quad . \quad (2)$$

where w is the true wire resistance of the whole line, and q is the resistance of the receiving instrument at the far end, Q.

Hence the current passing through this receiving instrument, which is $-\frac{dv}{dx}$ when x equals w, has the value,

$$\frac{2V}{(\sqrt{t}+q)\epsilon^{\frac{w}{\sqrt{t}}}-(\sqrt{t}-q)\epsilon^{-\frac{w}{\sqrt{t}}}};$$

and the magnetic effect, M, is proportional to this expression multiplied into $\sqrt{q}$. From this it may be shown that M is a maximum when

$$q=\sqrt{t}\,\frac{\epsilon^{\frac{w}{\sqrt{t}}}-\epsilon^{-\frac{w}{\sqrt{t}}}}{\epsilon^{\frac{w}{\sqrt{t}}}+\epsilon^{-\frac{w}{\sqrt{t}}}} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Now, if one end of the line be put direct to earth, we must make q equal to nought in equation (2). Under these circumstances the current $-\frac{dv}{dx}$ at any point x equals

$$\frac{V}{\sqrt{t}}\,\frac{\epsilon^{\frac{w-x}{\sqrt{t}}}+\epsilon^{\frac{x-w}{\sqrt{t}}}}{\epsilon^{\frac{w}{\sqrt{t}}}-\epsilon^{-\frac{w}{\sqrt{t}}}} \quad . \quad . \quad . \quad . \quad (4)$$

and therefore the current entering the other end of the line, where the potential is V_1, say, has the value,

$$\frac{V_1}{\sqrt{t}}\,\frac{\epsilon^{\frac{w}{\sqrt{t}}}+\epsilon^{-\frac{w}{\sqrt{t}}}}{\epsilon^{\frac{w}{\sqrt{t}}}-\epsilon^{-\frac{w}{\sqrt{t}}}} \quad . \quad . \quad . \quad (5)$$

If V_1 then be the potential at the point Q when the line is tested from the Q end and put direct to earth at the P end, Fig. 4, the apparent resistance of the line will be V_1 divided by the expression (5), and therefore equals

$$\sqrt{t}\,\frac{\epsilon^{\frac{w}{\sqrt{t}}}-\epsilon^{-\frac{w}{\sqrt{t}}}}{\epsilon^{\frac{w}{\sqrt{t}}}+\epsilon^{-\frac{w}{\sqrt{t}}}};$$

but this is exactly the same as the value found in (3) for q, which made M a maximum. Hence the receiving instrument ought to have a resistance equal to the apparent resistance of the line when tested at the receiving end and put direct to earth at the sending end.

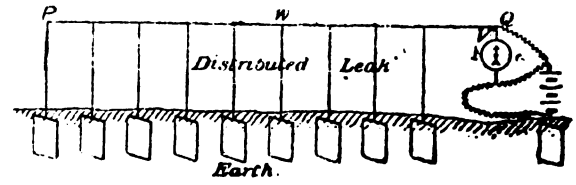

FIG. 4.

The resistance of the signalling battery does not in this case appear in the best value to give to q, but that arises from the fact that, whereas when we were dealing with a single earth fault we assumed that the signalling battery had a fixed E.M.F. and a fixed resistance, b, here we have assumed that V, the potential of the sending end of the line, was kept constant. Now this is the same thing as supposing that the signalling battery of fixed E.M.F. has an extremely low internal resistance. The two results are therefore the same.

3. Returning now to the general differential equation,

$$\frac{d^2v}{dx^2}=\frac{v}{F(x)} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

we see that, if the distributed leak may follow any law, $F(x)$ may be any function of x. The equation, therefore, cannot be integrated, and we must deal with the problem of determining the best resistance to give to the receiving instrument at the end of the leaky telegraph line without actually integrating equation (1), and without expressing in an explicit form the value of the current that passes through the receiving instrument.

To ascertain the general form of the solution of the above differential equation, whatever function $F(x)$ may be, let one solution be

$$v=\phi(x);$$

then

$$\frac{d^2\phi(x)}{dx^2}=\frac{\phi(x)}{F(x)} \quad . \quad . \quad . \quad . \quad (6)$$

Eliminating $F(x)$ from equations (1) and (6), we have

$$v\frac{d^2\phi(x)}{dx^2}-\phi(x)\frac{d^2v}{dx^2}=0;$$

$$\therefore \frac{d}{dx}\left\{v\frac{d\phi(x)}{dx}-\phi(x)\frac{dv}{dx}\right\}=0.$$

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and $v\frac{d\phi(x)}{dx} - \phi(x)\frac{dv}{dx} =$ some constant, say b;

$$\therefore \frac{d}{dx}\left\{\frac{v}{\phi(x)}\right\} = \frac{b}{\{\phi(x)\}^2},$$

or

$$\frac{v}{\phi(x)} = a + b\int\frac{dx}{\{\phi(x)\}^2};$$

$$\therefore v = a\phi(x) + b\psi(x) \quad . \quad (7)$$

is the general form of the solution of the original differential equation, the values of the constants, a and b, depending on the terminal conditions. In fact, as the differential equation No. 6 is linear, it is almost obvious, without any proof, that the general solution of this equation must be of the form given in (7).

In our particular case (Fig. 3) the terminal conditions are,

when $x = 0, \quad v = V,$

and when $x = w, \quad v = V';$

also, when x equals w, the current, A, flowing through the receiving instrument at the Q end of the line, or $-\frac{dv}{dx}$, equals $\frac{V'}{q}$.

$$\therefore V = a\phi(0) + b\psi(0) \quad . \quad . \quad . \quad (8)$$

and

$$V' = a\phi(w) + b\psi(w) \quad . \quad . \quad . \quad (9)$$

$$\therefore \frac{V'}{q} = -a\phi'(w) - b\psi'(w) \quad . \quad . \quad (10)$$

if we write $\phi'(w)$ and $\psi'(w)$ for $\frac{d\phi(w)}{dx}$ and $\frac{d\psi(w)}{dx}$ in the usual way.

Hence, eliminating V' from equations (9) and (10),

$$a\{\phi(w) + q\phi'(w)\} + b\{\psi(w) + q\psi'(w)\} = 0 \quad (11)$$

Eliminating b from equations (8) and (11),

$$a\{\phi(0)\psi(w) + q\phi(0)\psi'(w) - \psi(0)\phi(w) - q\psi(0)\phi'(w)\} = V\{\psi(w) + q\psi'(w)\} \quad . \quad . \quad . \quad (12)$$

also eliminating a from the same two equations,

$$b\{\psi(0)\phi(w) + q\psi(0)\phi'(w) - \phi(0)\psi(w) - q\phi(0)\psi'(w)\} = V\{\phi(w) + q\phi'(w)\} \quad . \quad . \quad . \quad (13)$$

therefore, substituting in equation (7) the values of a and b given by equations (12) and (13), we have

$$v = V\frac{\{\psi(w) + q\psi'(w)\}\phi(x) - \{\phi(w) + q\phi'(w)\}\psi(x)}{\phi(0)\psi(w) + q\phi(0)\psi'(w) - \psi(0)\phi(w) - q\psi(0)\phi'(w)}.$$

Now A, the current flowing through the receiving instrument at the Q end of the line, is $-\frac{dv}{dx}$, where x is made equal to w; therefore

$$A = V\frac{\psi(w)\phi'(w) - \phi(w)\psi'(w)}{\phi(0)\psi(w) + q\phi(0)\psi'(w) - \psi(0)\phi(w) - q\psi(0)\phi'(w)},$$

and the magnetic effect is proportional to A $\sqrt{q}$, and will, therefore be a maximum when

$$q = \frac{\phi(0)\psi(w) - \psi(0)\phi(w)}{\phi(0)\psi'(w) - \psi(0)\phi'(w)} \quad . \quad . \quad (14)$$

Next, let the line be put direct to earth at the P end, and the apparent resistance of the line, with its non-uniformly distributed leak, tested from the Q end, Fig. 4: then, if x be still reckoned from the P end of the line, the terminal conditions for determining the constants in the general solution,

$$v = a\phi(x) + b\psi(x) \quad . \quad . \quad . \quad . \quad (7)$$

are, when $x = 0, \quad v = 0,$

$$x = w, \quad v = V_1;$$

$$\therefore v = V_1\frac{\phi(0)\psi(x) - \psi(0)\phi(x)}{\phi(0)\psi(w) - \psi(0)\phi(w)};$$

and since the apparent resistance of the line tested from the Q end equals V_1 divided by $\frac{dv}{dx}$, when x is made equal to w, this apparent resistance will be—

$$\frac{\phi(0)\psi(w) - \psi(0)\phi(w)}{\phi(0)\psi'(w) - \psi(0)\phi'(w)};$$

but this is exactly the same as the value of q given in equation (14), that made the magnetic effect a maximum. Hence we may conclude that, whatever be the nature of a leak on a telegraph line, whether the leak be a single one, or be distributed along the line according to any law of distribution, the same rule holds true for the best resistance to give the receiving instrument—viz., the receiving instrument at either end should have a resistance equal to the apparent resistance of the line when tested from that end and put direct to earth at the other end.

In what precedes it is assumed that the resistance of a coil of wire occupying a given form and volume is proportional to the square of the number of convolutions. This is absolutely true either when the thickness of the insulating covering is negligible compared with the thickness of the copper, or when the ratio of thickness of the insulating coating to the diameter of the copper is constant for each gauge of wire employed. In a paper on galvanometers* published in the *Proceedings* of the Physical Society, examples are given of similar coils of silk-covered wire of very different resistances where this proportionality of resistance to the square of the number of windings holds very well. In some other cases, however, as will be seen by referring to that paper, the resistance is more nearly proportional to the number of windings raised to the power five halves.

It is therefore worth while considering how the rule given above for the test resistance for the receiving instrument would be varied if the coil of the receiving instrument were wound with such insulated covered wire that M, the magnetic effect, instead of being proportional to A $\sqrt{q}$, were proportional to A q^n. In that case it may be shown that M will be a maximum when

$$q = \frac{n}{1-n}\frac{\phi(0)\psi(w) - \psi(0)\phi(w)}{\phi(0)\psi'(w) - \psi(0)\phi'(w)};$$

and this is $\frac{n}{1-n}$ times the apparent resistance of the line when tested from the receiving end and put direct to earth at the signalling end.

ELECTRIC STATION ECONOMICS.†

BY PROF. D. C. JACKSON.

Small economies in electric station management and operation are things which have a peculiar faculty of swelling up to big totals, a fact of which wideawake managers with eyes to profitable running have had ample opportunity to satisfy themselves. One of the items entering largely into the question of economical operation is the equipment of station instruments. The term station instruments may be made to cover a variety of tools and indicating devices, from the coal-shovel to the main fuse block. The essential electrical instruments are such as will enable station men to handle dynamos and look after their regulation with the greatest precision, but with the expenditure of the least labour and with the least possibility of accident. With the usual construction, the electrical instruments are mounted collectively on a switchboard, but seldom in the best manner. Remember that accidents may involve, first, the operator; second, the plant; third, any branch of the plant.

Safety of Plant.

In discussing the subject recently before the North-Western Electrical Association, the author took occasion to point out that while safety for careful operators is usually provided, the safety of the plant itself is seldom considered. Fires, for example, have been far too frequent and disastrous in their occurrence. A great many of the fires in electric stations start at the switchboard. These can be made almost absolutely safe, and, with proper construction, switchboard fires should be almost unknown. How many stations have properly constructed switchboards? And how many stations pay a fairly low rate of insurance? A saving of 25 cent. on insurance rates will pay for considerable improvement in the switchboard. By making

* "Galvanometers," by Prof. Ayrton, T. Mather, and W. E. Sumpner, D.Sc., *Phil. Mag.*, July, 1890, page 86.

† From *Cassier's Magazine*.

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the improvements and insisting upon intelligent inspection by the insurance companies, the improved rates can be secured. At the same time a guarantee against fire is obtained.

This is better than insurance, for, however well the insurance companies may treat one after a fire, they will never repay all the losses incurred. Build switchboards of non-combustible material. Marble is not very expensive and is better than slate. If combustible material is used for the board, never make it solid, but arrange it simply as a skeleton upon which the instruments may be secured. Set the switchboard at least 2ft. (3ft. is better) from the wall, and have all the wiring done in the best possible manner and in plain sight. Under no circumstances close the ends of the space back of the board, making it into a sort of rubbish closet. Keep the space all around the board light and clean. Nothing will guarantee neat, safe wiring and safe storage of material except the entire absence from the station of dark corners and closets. There are, by the way, few station hands who will wire a switchboard in a neat and safe manner without excessive expense unless they are carefully directed.

The Switchboard.

The switchboard should be located conveniently and the instruments conveniently placed thereon. The dynamo instruments should be bunched together, and the different devices belonging to each individual dynamo circuit should be placed in vertical rows. This avoids the probability of the accidents to machinery which are bound to occur when the instruments are irregularly distributed. System at the switchboard is just as important to economy as is system in the accounting methods. Pressure indicators, cutting in galvanometers, ground detectors, and other instruments which are common to all the dynamos should be placed where they are easily seen by a man at the dynamo regulators. Devices placed in the feeder circuits may be placed either above or at one side of the dynamo instruments. In any case, the arrangement should be such that extensions may be readily made.

The number of instruments on the dynamo and feeder circuits should never be multiplied unnecessarily. Their type and number in any case depends upon the type of the apparatus, and the purpose for which it is used. Thus arc light plants require an arrangement which differs completely from that which is required in alternating incandescent stations, and the latter differs from that required in stations supplying a continuous-current constant-pressure distribution. If arc light dynamos with separate regulators or controllers are used, these should be solidly mounted near the dynamos to which they belong. In each case the maximum of safety and convenience should be sought in the choice and arrangement of the instruments. The arrangement of the standard panel switchboards of two or three prominent manufacturing companies may be followed with profit. Where two or more classes of machinery are used, the different types of dynamos should be set together and the switchboards should be distinct, but side by side.

The Steam Question.

Let us drop the electrical question now and go over to the steam side. We will start with the coal-bin and simply touch upon the instruments or tools not generally used, but which can usually be advantageously added to the equipment—that is, which are likely to add to the dividend-paying capacity of the station. The first instrument on this list is a platform scale for weighing in the coal. Daily records of coal consumed should be carefully kept and compared with records of the electrical output, day by day, week by week, and month by month. Complete daily records enable a station manager to readily determine whether he is getting the results with the least expense. The coal records also enable a direct comparison of the economy of the different grades of coal. Many station managers give too little attention to this matter, simply purchasing the grade of coal which happens to have the lowest price per ton. This is frequently all right, but sometimes it is not economical.

The coal-shovel is an instrument which requires a great deal of careful supervision. The coal records and automatic records of steam pressure serve this purpose. An automatic steam-pressure recorder is not an expensive instrument. If one is properly installed and its indications are acted upon by the manager, it will soon save its cost. There are various automatic recorders. A first-rate one is the Bristol. The Edison, which is more expensive, has some advantages which are, however, of little moment in a small plant. Those who have operated stations both where pressure recorders are and are not used, will doubtless be ready to bear witness to their advantages. Thermometers in the feed-water pipe and in the steam-pipe are not essential to the operation of a station, but they are certainly advantageous. A throttling calorimeter made of ordinary fittings is also serviceable. The use of the thermometers and calorimeter may look like kid-glove engineering, but if one is anxious to get the best result from a steam plant for the least cost, they should be employed. They are not kid-glove affairs, but good common-sense appliances. Steam-gauges on the boilers (good reliable ones) all will agree are essential, but it is not usual to put one in the steam-pipe near the engine. It is a good idea, however.

I am acquainted with a plant of considerable size which operates 24 hours a day. During daylight the load on the plant is small, and in such cases it is the impulse of the average fireman and engineman to throttle the steam by partially closing the boiler valve. In the station I speak of the reduction in the pressure is 20lb. Let us see the result. In first bringing the boiler pressure up to 100lb. above the atmosphere a certain amount of heat is furnished to the steam from the fuel. Where the pressure is reduced by throttling, the steam is cooled to a lower temperature and some of the heat contained in the high-pressure steam is lost. This loss means an equal decrease in the power of the steam, and, therefore, the coal which was used in raising the pressure from the low figure to the high one is simply thrown away. When it is necessary on account of light day loads, it is much more economical to lower the boiler pressure to a satisfactory figure. In the station referred to the loss in fuel on account of throttling was from 5 to 10 per cent. Five to 10 per cent. of the fuel used on day load makes a considerable item in the period of a year, which will pay for the recording boiler gauge and a gauge in the engine pipe, besides adding a sum to the dividend account. It is true that the gauge in the engine pipe does not remove the fireman's impulse to reduce pressure by throttling, but if his work is constantly under inspection the impulse is much less likely to be irresistible. In this connection let me remark regarding the usual practice of cutting off the condenser at times of light load when condensing engines are used. Under such circumstances fuel is saved by keeping the condensers running, but reducing the boiler pressure to hold the engine cut-off at an economical point.

The Engine Indicator.

Another instrument of much value is the engine indicator. This is particularly useful in determining whether the engines are working at their most economical cut-off, and whether the valves are properly set. A great many engineers tinker with their engine valves, and rely upon their eye and ear to set them properly. This is generally poor economy, and the indicators should be brought into requisition. If cards are taken at fixed intervals and filed for reference, they may be made a decided aid in the effort to keep everything at the most economical point. In the valve setting alone, if the indicator can point out the way of saving a very small per cent. of fuel, it will quickly pay for itself in this country of expensive coal. The horse-power calculated from the diagrams, compared with water and fuel records, and again with electrical records, give all the elements necessary for determining at any time whether the plant is doing its duty satisfactorily.

I have spoken particularly of instruments that are frequently not used in the stations, but which can be made of much valuable assistance in reducing expenses. These are not varnished, theoretical ideas, but hard, common-sense, dividend-earning suggestions. They can be put into service without increasing the operating costs in any way, and the instruments will ordinarily quickly pay for themselves.

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THE GENOA ELECTRIC TRAMWAY.

During the course of last year an electric tramway on the overhead trolley system was constructed and set in operation at Genoa. This line has been described by M. L. Respighi in the columns of an Italian contemporary, *L'Elettricista*. The ample precautions which have been taken to ensure a safe and efficient service have prevented any disturbances being set up in the telephone circuits, which are carried parallel with the tramway. The feeders are carried on brackets attached to the walls of the houses, and the transverse wires supporting the trolley wire are arranged at a height of 23ft. from the ground.

The tramway is worked under a concession granted by the municipality of Genoa to the Electric and Cable Railway Company of Kerns, Switzerland. The concession authorises a line from the place Corvetto to the place Manin, through the rue Assarotti, which is already in operation, and which has to be extended so as to reach the generating station; and a line from the place Corvetto, through the rue San Filippa and San Giacomo, la rue Serra and la place Brignole. Considerable difficulties were encountered in the carrying out of the first-mentioned line. The rue Assarotti extends in a straight line, with an incline varying between 6, 7, and 8 per cent. Each car with a load of 25 passengers had to travel at 7½ miles an hour, and to stop at several points on the route both in making ascents and descents. It was considered to be impossible for the line to be worked other than by electric power.

The capacity of the station is 450 h.p., with three boilers, three engines, and three dynamos, one of each of which is kept as reserve. At present only two boilers, one engine, and one dynamo are in use, this plant being sufficient to operate the line of tramway now worked. The engine, which was made by Messrs. Tosi, is of the compound type. The boilers are of the Cornovaglia type, working at 157lb. pressure, and fed by means of two duplex steam-pumps. The dynamos are of the Siemens and Halske compound type, giving at 420 revolutions a current of 200 amperes at 525 volts.

The main cable is carried on insulators fixed to wooden posts as far as the place Manin, where the head of the line of tramways is situated; it is 1,250 metres in length, and is supported on posts at intervals of 40 metres. This cable contains eight wires of 7·5mm. diameter. At the place Manin four of these wires are united and soldered to the rails, which are of the Phénix type; the other four wires serve as feeders to the service or trolley wire. One single wire really suffices for the working of the line in operation, and two other wires cross the town and terminate at the end of the line in the place Brignole, so as to furnish current to the tramway in the rue Serra. Another feed wire will be carried to operate the motor of the cable line to be built.

Great precautions have been taken in constructing the tramway so as to ensure perfect insulation. With regard to the line, the brackets, which are of iron, are fixed to the wall by means of a circular plate and four bolts. The vertical rods which support the insulators are fixed to and insulated from the brackets. The transverse wires carrying the service or trolley wire are of galvanised iron, arranged at intervals of from 40 metres to 50 metres. The service wire is of phosphor bronze, 7·5mm. diameter, and instead of using a trolley wheel, a wire is used to collect the current; this contact wire is a simple iron wire, 8mm. diameter, passing over the service wire, and is said to answer its purpose exceedingly well.

The cars are lighted by means of five 16-c.p. incandescent lamps energised from the line. Each car is equipped with two 18-h.p. motors of the Siemens and Halske type. The gearing consists of an endless screw connected to the armature shaft, and engaging with a toothed wheel carried on the car axle.

There are at present four electric cars in operation. The electrical equipment was furnished by Messrs. Siemens and Halske, and the tramway was carried out under the superintendence of Mr. W. Reichel, of that firm. It is intended to place 24 cars on the other lines now in course of construction, and of which six will shortly be placed on the Corvetto-Stagliano route.

COST OF PRODUCING ELECTRICITY.

A committee on data is maintained by the National Electric Light Association, and during the past year the committee have endeavoured to collect information relative to the cost of running electric supply stations in terms of coal consumed per watt-hour.

The committee was requested to furnish the convention with the facts regarding the amount of coal used in actual practice to produce a given quantity of electricity. The information was obtained by correspondence, and furnished the committee in amperes, volts, and hours on each circuit, and the amount of coal used covering this period, including that used for banking fires, etc. The aggregate electrical output for 24 hours was then calculated and compared with the total amount of fuel used, giving the watt-hours per pound of coal. All improbable and apparently erroneous reports were discarded, and the tabulated statement submitted in the committee's report comprises intelligent replies from a large number of the electric stations, including many of the leading corporations. The great saving in operating in large units and running continuously is plainly evident from the report which shows 208 watt-hours per pound of hard screenings where about 8,000,000 watts were generated, running full 24 hours, as against the report which claims only 30 watt-hours per pound of soft coal, the total output being less than 60,000 watts, and the service being furnished only seven hours. The best reports do not compare favourably with the results secured in generating power for manufacturing purposes.

In order to facilitate this comparison, the committee prepared a table based on 90 per cent. mechanical efficiency in the engine, and the same efficiency in the dynamo. Then

$$\frac{746 \times \cdot 90 \times \cdot 90}{\text{coal per hour}} = \text{watt-hours per pound of coal.}$$

And

Coal per hour per i.h.p.				Watt-hours per pound of coal.
1·5lb.	should	produce		402·84
2	,,	,,	,,	302·13
3	,,	,,	,,	201·42
4	,,	,,	,,	151 06
5	,,	,,	,,	120·85
6	,,	,,	,,	100·71
7	,,	,,	,,	86·32
8	,,	,,	,,	75·53
9	,,	,,	,,	67·14
10	,,	,,	,,	60·43
11	,,	,,	,,	54·93
12	,,	,,	,,	50·35
15	,,	,,	,,	40·28
18	,,	,,	,,	33·57
20	,,	,,	,,	30·22

From this estimate of engine and dynamo loss, 1½lb. of coal should produce 402·24 watt-hours. The committee had a report from the Chelsea Jute Mills, of Brooklyn, N.Y., covering a period of six days, where an average of 653·3 i.h.p. was developed from a coal consumption of 1·482lb. per indicated horse-power per hour, the load varying from 495·21 h.p. to 764·96 h.p. This equipment consists of Corliss compound condensing engines and vertical tubular boilers. The plant was in operation 10 hours each day. The figures given cover the whole amount of fuel used, including banking, etc. The fuel was George's Creek bituminous coal.

If the committee's percentage of efficiency is correct, and if a fairly uniform electrical output could be obtained, this plant, the *Electrical Review* of New York says, ought to produce over 400 watt-hours, or double that of the most favourable report given in the committee's tabulated statement, more than double that of the next best report, thirteen times the efficiency of the plant making the lowest report, and between four and five times the average efficiency of the whole report. The report shows an average of 91·7 watt-hours per pound of coal—a very low average indeed—thus requiring the consumption of nearly 7lb. of coal per indicated horse-power.

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STORAGE BATTERIES IN CENTRAL STATIONS.

At the recent meeting of the National Electric Light Association at Washington, the question of using storage batteries in central electric light stations was brought forward for general discussion, no paper on the subject being presented. The following is a report of the discussion.

Mr. BRACKEN, of New York, said: As one who has been associated with the storage battery interests in this country from its inception, I have been asked by a number of storage battery representatives to open this discussion with a few preliminary remarks. I understand to-day the subject will be confined to their use in central stations. I am afraid that most of the storage battery men will approach this subject with some degree of diffidence by reasonable scepticism that exists in the minds of a very large percentage of the central-station men about storage batteries. Peace now reigns over the storage battery interests in this country. The companies have come in under one flag, and are united for a common interest, so that you may purchase a storage battery to-day with the confidence that that you are not going to be annoyed by threats of suits for infringement. You not only have the advantage of peace, but you also have the advantage of the experience which has been gained both in this country and in Europe by these companies. We had the representatives of several foreign companies here this summer, and we got a great deal of useful information from them. It is also natural that you should desire a certain guarantee as to the cost of maintenance and efficiency of the batteries. As to the nature of the guarantees, any persons desiring to instal a storage battery plant in his station can readily satisfy himself as to the life of the plants. He can then guide himself by getting proper guarantees as to the cost of maintenance. I do not think there is any company asking a larger percentage than 10 per cent. for the cost of maintaining the battery. I have no doubt that experience will prove the cost of maintenance to be less.

Mr. P. G. SALOM observed: The question of the advisability of the use of storage batteries at the present time in central-station plants is purely a commercial one. Will it pay? All of you agree that storage batteries are a desirable adjunct to have in central-station practice, but you are deterred for two reasons. First, you do not know positively that the investment will show a decrease in operating expenses; and, second, you are still more uncertain as to the cost of maintenance of the plant after you have made the investment. Now, in order to answer these questions intelligently, the first requisite in this or any other quantitative determination is to have a unit or standard. This unit or standard is the cost of producing a given quantity of electrical energy under certain normal and fixed conditions. In other words, given a standard engine and dynamo of the average size used in central stations, what is the cost per kilowatt-hour or ampere-hour? Having determined this cost, based on a given price for coal and labour, each central-station operator can determine at the end of the year how closely he approximates this ideal cost by dividing his total output into his total operating expenses, and, further, by keeping careful records he can also determine what factor or factors are operating to prevent his attaining the ideal results. For example, if by reason of his geographical location his coal costs him twice as much as the price assumed in the original estimate, his operating expenses will be increased proportionally, and if they exceed this additional amount he must look to other factors to explain the increase. Having determined all these factors for his own individual case, it becomes a simple question of arithmetic for him to determine whether with an additional investment for a battery with a given output and efficiency and at a given cost for maintenance, he can advantageously add to his plant a storage battery. No hard and fast rule can be adopted. No two central stations are alike, either in equipment or output, and, therefore, the best size of battery equipment or proper proportion of battery to other units may never be exactly the same in any two cases. Now, the second question may be briefly answered by the statement that we are now prepared to give responsible guarantee that the maintenance of the battery shall not exceed a certain reasonable cost per annum, and which, of course, has been duly considered in estimating the additional cost and savings of a storage battery plant.

Mr. J. APPLETON said: The Germantown Electric Light Company had the distinction of being the first electric lighting company to use a storage battery equipment of American manufacture and design. The company had a day load of incandescent lamps and motors on the three-wire system which was very unprofitable, and about 15 months ago they decided to try the use of a storage battery to see if the day load could not be made profitable instead of a dead loss. A small battery was put in sufficient to carry the day load; its capacity was 800 ampere-hours with a normal rate of discharge of 80 amperes. The machinery was then shut down from daylight till dusk, the battery taking care of the day load. This being an experiment to ascertain the true facts about the working and value of a storage battery for central-station purpose, very careful figures were kept, and the result of the first year's working was eminently successful and resulted in a large saving. According to Mr. Allen, the superintendent of the station, the saving on the one year's running in labour, coal, water, oil, waste, etc., not counting the decreased depreciation of machinery due to shutting down from daylight to dusk, was 2,500dol. Besides this there was a great advantage in being able to overhaul and examine all machinery in the daytime while everything was shut down. This being so satisfactory, and the behaviour of the battery being equally good, the Germantown company decided to put in a battery of 2½ times this capacity, which would enable it to increase the day load and consequently increase the savings, as the cost of charging a large battery is only the extra fuel required. This larger battery was installed at the beginning of this year, and is the one which I will now describe. The battery consists of 120 cells of the chloride type G, 11 plates in each, arranged 60 on each side of the three-wire system. The capacity of the cell is 1,000 ampere-hours, or 2,000 hours with both sides. The normal rate of discharge is 200 amperes, maximum 400, and this can safely be increased in case of sudden demand or emergency. The plates are protected by the improved asbestos insulation, and are contained in lead-lined wood tanks. An asphalte floor, well drained, is provided, so that there is no trouble in handling the acid. One special feature of these cells is the size of the plates, 15in. square. Anyone who has had experience with storage battery will appreciate this point, and will readily understand how much less trouble and expense there is in the maintenance, when only 11 plates are required to give 1,000 ampere-hours' capacity instead of about 80 plates. Plates of the chloride type can be constructed larger than this without any difficulty, and give equally good results. This battery plant has been designed to meet all the requirements of the three-wire system, and to give the greatest possible flexibility. The ordinary course of working in the Germantown station is as follows: The machinery is shut down at daylight and the battery carries the whole of the day load till dusk, when the dynamos are started again. The battery is then switched out during the hours of heavy load, and started in again for charging when the load decreases. By this means the general plant is working at an efficient load during all the hours it is running, and the extra fuel for charging the battery is hardly noticeable. The daily routine is very simple; the discharge of the battery is noted by hourly readings, and at the end of the day the total discharge is ascertained. A charge of about 10 per cent. in excess of the discharge is put in, and this is found to be sufficient. In some cases even less charge than this will bring the cells up to the proper E.M.F. Just before the end of the charge readings are taken in some of the cells with the hydrometer and voltmeter, and the condition of a cell can be accurately ascertained. The maintenance of a storage battery is the point which frightens most engineers. In the old days 46, 50, and 60 per cent. efficiency was the average result, and this, I believe, is the chief reason of the slow adoption of the batteries. Until recently, sufficient attention was not paid to designing the cells for the work they had to do. Engines and dynamos

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are designed and installed according to the nature of the work they have to perform, and this must be done with batteries. Given a properly designed and installed battery, such as the one I have described, the maintenance and depreciation will not exceed that of the other portion of the central-station plant. A storage battery does require attention, but not skilled attendance. The most important thing is to give it regular attention. Do not leave it for weeks or months till some fault develops, but treat it like other machinery, overhaul it regularly, and prevent the occurrence of any fault. A method I have found to be very good in looking after large battery plants is to have voltmeter and hydrometer readings regularly, say, once or twice a week, and every day overhaul thoroughly one cell, emptying out the acid, cleaning, if necessary, and putting everything in proper order. By doing this in the proper rotation every cell is examined, say, twice a year, yet the time required is hardly noticed, being only an hour or so every day. In this way the efficiency of a battery can be kept high, and results obtained which will put on very different complexion in some electric light stations. There are many stations in this country which are running the day load at a loss, or are losing business by not supplying current at all in the day. To these stations a battery plant would be invaluable, and would give a very different result when the balance-sheet is taken off. In many cases it would be best, of course, to leave the battery in the line always, and then when the general plant is running the battery acts as a regulator, taking up any fluctuation in the load, relieving the generating plant and keeping the potential constant. Again, in some stations the load curve takes the form of a sharp peak for a short time during the evening, when most of the lights are in use. A battery will assist the dynamos during the period of maximum load, and it removes the necessity of providing a generating plant which will only be used for a very short time during the 24 hours, standing idle and unprofitable the remainder. There is another question, too, which electric light men have to face: how can we profitably reach the outlying districts with our direct-current main? Here, again, the battery plant proves valuable; small sub-stations in the outlying districts can be built for the batteries, and these can be charged in series at, say, 400 or 500 volts, and the current distributed at the required pressure.

Mr. DeCamp observed: I happen to know something about the condition of the Germantown plant. The objection seems to be that they had an unprofitable day load that prevented them from making any money or as much money as they thought the station ought to earn. I think that came from the fact that before going into the day business the station had been fairly profitable. But looking into that matter one time for a friend of mine who was interested, I concluded that the loss of the day load was sufficiently absorbed by the profit on the profitable part of the business, and I so stated. I heard nothing more of it until the batteries were introduced, and I have been told by the company that that has stopped this loss. Now, I would like to know whether in the experience with the battery—because it is a small one, it takes up about the day load of the business, as I understand it—whether the use of the battery has done anything more than to save the loss which the station made while it was running an unprofitable day circuit: or, in other words, knowing what the profits or results of the station were previously to the introduction of the day business, have the real substantial results increased since the introduction of the batteries in proportion to the increase of their business, or whether it has simply been a saver of what they lost.

Mr. Nicholls remarked: I have a question that I think can be answered at the same time. Some of the gentlemen—one, at all events—referred to the Germantown station and set forth the great advantages gained by reason of the storage battery taking care of the day load; that previously it was necessary to run the dynamo to take care of that load, and, if I understood him correctly, it took about 60 amperes. As I understand it, that was an ideal case in which a storage battery could work to advantage. I am very much interested and have been giving a good deal of consideration to the storage battery question. We have quite a heavy day load. It would not pay us to run a day load with the storage batteries. The day load we run on the three-wire system, the same as we run our lights, with 600 amperes. It will average at the present time all through the night, from 12 o'clock to 7 o'clock in the morning about 700 to 800 amperes. If we could have an accumulator to take care of that load, it would be an advantage to shut down our station and do with one shift of hands. My difficulties may be the same as the other gentlemen of the convention, and if anyone interested can give us the information we require, it would be an advantage to us.

Mr. Wright said: I am connected in a semi-official capacity with the Germantown Electric Company. As you have been told, in December, 1892, that company adopted a chloride battery. The battery was not put in before we had thoroughly informed ourselves as to the amount we were losing from the operation of the day circuit. We made very careful tests. All the stations with which I am connected are conducted on the continuous-day principle. We weigh the coal, measure the water, count the carbons, and we get it down just as fine as we can. We had the benefit of the continuous test at Germantown, supplemented by a test of two weeks' duration, which I made myself on the day circuit. I found that the amount paid for the day circuit was exactly the amount of our total loss by the entire incandescent business, which is composed almost half and half of direct current (220 volts) and alternating current (1,100 volts) distribution. You can readily see that amount of income from the day circuit should be added to that amount, and the loss from the day circuit should be the amount remaining. I am not at liberty to state this amount. But the year's experience showed a saving which has been stated as somewhere around 2,500dol., and that saving is only figured on the rougher items, and figured from my memory, as I did not have the exact particulars with me. There are some items, such as incandescent lamp renewals, which you can readily see would enter in, that were not included. The amount saved by the year's operation of the storage battery amounts to 700dol. The output was small. The average output on each side would be from 30 to 40 amperes from dawn to dusk. I would say, further, that the amount of direct-current distribution is just one-half the incandescent business of the station. There is one point about this battery that I ought to mention. At Germantown we have doubled the lamp capacity of our dynamos. The load figures for December showed us that if we were going to do as well this year as last year in the way of extension, we would have to look out and put in more direct-current machinery, and in the annual estimate that was included.

Mr. Barstow asked: What was the rate of interest figured on the investment?

Mr. Wright replied that when the old battery was put in, only 25 per cent., or rather the depreciation was figured at 25 per cent., we allowing for that depreciation. The new battery earned about 35 per cent. on the amount of the investment during the year it was in operation.

Mr. Nicholls: You say that it showed a depreciation of 25 per cent. in one year—will you explain that?

Mr. Wright said: I would rather not answer that question, and I may as well state the reason. Battery No. 1 was put in. It was a very small battery. I have said that the average load was about 40 amperes. The load at times during last summer, when we had motors, got over 200 amperes, and that battery had to do the work. I cannot speak of the depreciation, for the reason that the battery was taken out, and the battery was not in as good shape as when it was put in. We could see evidence of the depreciation, but we have sufficient faith in the battery after one year's experience to put in a battery with two and a half times the capacity. We started with the smallest battery we could buy, but we could not limit our output. Our output consisted of motors for testing, and the current was "out of sight" as compared with the capacity of the battery. I considered that the conditions for the operation of that battery were adverse, and while it showed from a condition of depreciation when it was taken out after a year's service, the evidence was sufficient to warrant us in sending for one having two and a half times the capacity.

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THE
ELECTRICAL ENGINEER.

Published every Friday.
Price Threepence; Post Free, Threepence Halfpenny.
Editorial and Publishing Offices:
139-140, SALISBURY COURT, FLEET STREET, LONDON, E.C.

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A SILVER LINING.

We have been constrained lately to give considerable prominence to the sayings and doings of our cousins across the Atlantic, because in their meetings they are given to discuss practical questions. Although, however, there are a number of questions thus discussed which might well claim our attention, there is at home a question of the greatest promise which cannot be neglected. It is well known that our sympathies are in favour of municipal action whenever such action is possible, but there are numbers of cases where such action is impossible, the work being handed over to private adventurers. The question, then, is, ought investors to support supply companies? and we think the answer is an emphatic "yes," when such companies are intended for real work and not for mere Stock Exchange transactions. Leaving aside the question of municipal action, it may be well to consider the prospects of an investor in a well-conducted supply company. It ought never to be forgotten that the initial outlay in equipping a central station is large, out of all proportion to its immediate return. You must equip partly for the future as well as for the present. Thus the total capital expenditure is not immediately remunerative. But how is this matter working out? Experience is showing that within a very short period the well-conducted concerns are paying smaller or larger dividends to their shareholders; hence, as time passes on and the business is more and more developed, the investors will be in a position not worse than those who have invested in gas concerns. The quantity of energy consumed is bound to increase, and even when reduction in price is made experience shows that the total return is very soon augmented. If the management is wide awake, the shareholders more probably gain by reducing the price than lose. It may cost threepence per unit to generate and distribute a couple of million of units, which may be sold at sixpence, thus giving a gross return of fifty thousand pounds at a cost of twenty-five thousand pounds—a net return of twenty-five thousand pounds. A reduction to fivepence as the selling price, if it double the quantity sold, might enable and possibly would enable it to be produced at twopence halfpenny per unit, when the net return would be over forty-one thousand pounds as against twenty-five thousand pounds at the higher price. A high selling price in several instances is killing the enterprise, when a much lower price would probably return large profits. What we are endeavouring to show is this: that investors ought to be gratified rather than frightened at the necessarily large initial outlay on central stations—in fact, we are almost inclined to say the larger the outlay judiciously and properly expended, the better; as this outlay will fructify at even more than compound interest. Again, that they ought to support the management in proposing low prices to encourage a large output rather than to support higher prices and a small output. Of course, this question is one to be considered in connection with locality, and cannot be determined in offhand fashion by irresponsible

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journalists as an abstract question. We merely desire to indicate the views which we should like investors to take. The distribution of electrical energy from supply stations is a business that *must* grow, and as the expenses do not grow proportionately to the supply, the net returns for the shareholders must also grow: so that if a small dividend can be earned in early days, the probability is that a good—and continuously so—dividend may be expected later on. Hence we welcome the initiation of the companies which have been, and are, and will be put before the public. This does not mean that everything will continue to be good. Unfortunately, we must expect that, with a revival of confidence in good things, an attempt will be made to float others not so good, and a careful examination must be made of each prospectus as it comes before the public.

THE HERMITE SYSTEM AT WORTHING.

We give elsewhere the report of Dr. Kelly, medical officer of health to the Town Council of Worthing, on the Hermite method of treating sewage. We give this report because the true value of a system can only be known by considering what is said against it as well as what is said for it. As will be seen from our note columns, Mr. Cooper has protested against this report as containing erroneous conclusions. It rests with Dr. Klein and Mr. Cooper to support their respective views, but we cannot help thinking that so important a subject as sewage treatment by electrolytic methods has not received the consideration due to it. Both Webster's and Hermite's systems are benefited by a secondary action—in the one oxygen is evolved in large quantities, in the other chlorine. Still, the exact method of action is not what we want to know. Town councils and sanitary officers must first be satisfied that the system is effective, and then comes the question, at what price? The latter is really of less importance than the former, for with the increase of town population some method of treating sewage other than those in vogue now must come into operation. Our impression is that electricity will be the active agent that will be used, hence our desire to see the whole question calmly thrashed out.

THE FRENCH CHAMBER OF ELECTRICAL INDUSTRIES.

A report is given in the *Bulletin International de l'Electricité* of a recent meeting of the Chambre Syndicale des Industries Electrique, a body which corresponds to our Electrical Section of the London Chamber of Commerce. The President stated he had received a communication from the police referring to a fire which had resulted from a short-circuit in a building, and suggesting that the attention of electricians should be called to the measures of precaution which should be observed in such matters. The speaker had profited by the circumstance to call the attention of the authorities to the utility of the Bureau de Contrôle, established by the Chamber to prevent such accidents.

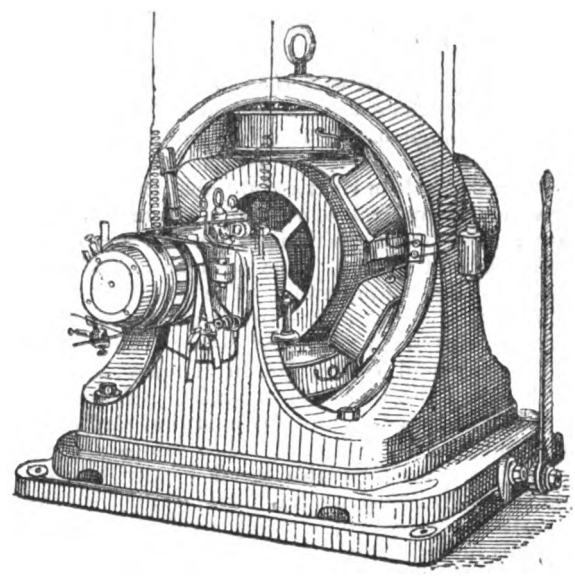
The president informed the members that the Chamber of Deputies had appointed a commission, with M. Georges Berger as president, to enquire into projected legislation on the laying and arrangement of electrical mains. It was to the interests of electrical industries to amend as far as possible the text of the proposals of the authorities, although the wording had already been conceived in a liberal spirit. It would be advisable, for instance, to get inserted a new clause providing that in the case of the Government having to modify its telephone lines owing to the establishment of new conductors for the service of the public, such as electric tramways, the cost of the same should not fall upon the *concessionaires*.

Mr. Picou, the director of the Bureau de Contrôle, next gave an account of its operations during the season. They had subscribers on January 1 amounting to 13,500 lamps. The number of visits made to installations was 101, and the number of tests of meters made was 77. The receipts of all kinds amounted to 14,597f., or, say, £584. This was a satisfactory result, and a good development was anticipated. A modification of the tariff was agreed to.

The question of taking part in the Antwerp Exhibition was considered. A committee was appointed to enquire into the advisability of a proposal which was made that a joint display should be made by French electricians, it being argued that greater economy could thus be effected than by independent exhibits, besides other advantages being attained.

A NEW DIRECT-CURRENT ARC GENERATOR.*

The results of extended and elaborate experiments, carried on for a long time by the Westinghouse Electrical and Manufacturing Company, with a view of obtaining a dynamo that would better fulfil the requirements of direct-current arc lighting than any heretofore in use, are embodied in its new direct-current arc machine, which we illustrate.



Though the new machine differs very radically in construction from former types, it belongs to the well-known open-coil continuous-current class, which is acknowledged to offer special advantages for arc lighting work.

A machine of this class delivers a uni-directional though not continuous current, for while the E.M.F. of the terminals does not change its sign, it, nevertheless, pulsates or fluctuates. This pulsation of the E.M.F. gives a steady mean value to the current, and makes it particularly adapted for arc lighting, as its pulsating character keeps the mechanism of the lamps in a slight but constant vibration, thereby rendering them less liable to become slow in action or altogether fail to feed.

The new machine in general appearance is similar to the Westinghouse standard alternating-current dynamos—that is, it consists of a circular cast-iron yoke parted horizontally and having inwardly projecting poles. The armature is of the toothed type with lathe-wound coils, especially heavily insulated.

The public are thoroughly familiar with the advantages of the toothed armature, which avoids the use of band

* From the *Electrical World*.

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wires and allows the replacing of an injured coil with but small outlay of time and money. The use of lathe-wound armature coils secures any desired degree of insulation—a most important point in the construction of every arc dynamo. The armature is supported in self-oiling bearings with spherical seat, so that the machines are self-aligning. The bearings are cast solid with the lower half of the field, thereby securing great strength and rigidity of construction.

A particularly strong point claimed for the machine is the system of regulation. It has absolutely no regulating devices or wall traps, such as have heretofore been the accompaniments of all constant-current machines. Regulation is effected, as in the Westinghouse alternating-current arc machines, by the reactive effect between the winding of the field and the armature. The generator may be short-circuited and run without injury, and is absolutely self-regulating throughout its entire range of load.

With the use of direct currents, the commutator has always been considered the weak point of the system. Consequently, particular attention has been paid to the securing of satisfactory results here. This has been accomplished by the use of a new-type commutator, which presents a large bearing surface for the brushes, and which has the segments separated by $\frac{1}{2}$in. of insulation, so that the machine is particularly free from vicious sparking. Four sets of copper brushes collect the current without the use of "blow-outs" or other troublesome devices intended to avoid sparking.

The field coils are connected in series with one another. The exciting current is supplied from a separate low-voltage machine, so that the use of high potentials in the field windings—a menace to insulation and life—is avoided. An efficiency of over 90 per cent. is claimed for the new machines, which far exceeds anything heretofore available, as the best direct-current series arc machines are ordinarily very inefficient. The speed varies from 750 revolutions for 60-arc 9$\frac{1}{2}$-ampere machines to 950 revolutions for 25-arc machines.

The lamps supplied with the machine are of the rack feed type, affording the excellent method of regulation secured in the Westinghouse constant-potential lamps. In the construction of these lamps particular attention has been paid to making them rigid and durable, thus enabling them to give long continued service with a minimum amount of repairs. The lamps are designed to suit the requirements of all kinds of service. The outdoor lamps are plain in appearance, but weatherproof. The indoor lamps are made in a variety of forms with brass or galvanised iron mountings, and with plain or fancy globes. The lamps use a plain or coppered carbon $\frac{5}{8}$in. in diameter, and they will give 14 hours' life with one trimming. These lamps are designed to be used on any direct-current series arc system which supplies 9$\frac{1}{2}$ amperes. The lamps are supported from strong non-combustible metal hanger boards. Each lamp is supplied with an automatic cut-out, so that when the carbons are burned, or if any accident happens to the lamp, it is automatically cut out of circuit without disturbing the other lamps in use.

POLYPHASE TRANSMISSION.*

BY CHARLES F. SCOTT.

(Continued from page 375.)

The curves show that if the power factor be 100 per cent., as it is with incandescent lamps, the inductive drops for various counter or inductive E.M.F.'s are ·02 per cent. for 2 per cent.; ·08 per cent. for 4 per cent.; ·18 per cent. for 6 per cent.; ·32 per cent. for 8 per cent.; ·50 per cent. for 10 per cent.; 1·2 per cent. for 15 per cent.; and 2·0 per cent. for 20 per cent. The curves show that the drop increases very rapidly at first if the power factor becomes less. These relations may be elegantly determined by a simple diagram on section paper ruled in tenths. Draw an arc through a quadrant with a radius of 100. At a distance from the centre on the horizontal, equal to the power factor of the load, erect a perpendicular and extend it to the arc. This line represents the counter E.M.F. of the load, and its value, read directly on the scale, gives the counter E.M.F. in per cent. of the E.M.F. upon the load. From the intersection of the arc draw a horizontal line outside the circle, equal on the scale divisions to the per cent. in terms of the E.M.F. on the load which would be required for sending the normal amperes continuous current through the line resistance.

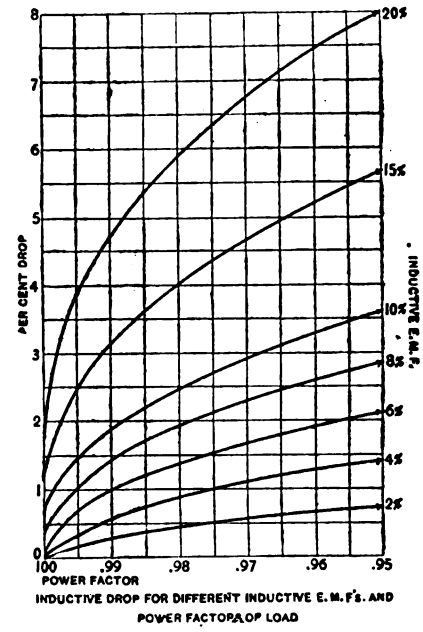

FIG. 12B.

From the end of this horizontal line draw an upward vertical equal to the counter E.M.F. of the line expressed in per cent. of the E.M.F. on the load. A line from the centre to the upper end of this vertical represents in direction and magnitude the E.M.F. which must be impressed on the circuit. If, from the same centre, an arc be drawn through this point to the base, the scale divisions on the base between the two arcs measures the total drop caused by the line in terms of the E.M.F. on the load.

SELF-INDUCTION IN TRANSFORMERS, ETC.

Self-induction exists in line, generators, transformers, secondary wiring, and sometimes in the load. In each case the effect of the self-induction upon regulation depends largely upon the self-induction of the total load which it supplies. Thus, the regulation of a generator depends upon the total self-induction of the line, transformers, and load. Again, the regulation of a line supplying converters depends both upon self-induction of the converters as well as that of the useful load. The same analysis, diagrams, and tables which have been used above in connection with the line will apply to the transformers and approximately to the regulation of the generator.

An ordinary transformer has primary self-induction and a secondary self-induction and a mutual induction, which becomes a ready source of very complicated and perplexing analysis when the complete action is described in theoretical terms. Practically, however, the action of the self-induction in the transformer may be expressed in a very simple way, and it is readily seen that this self-induction has a very important bearing upon the regulation of the transformer. The regulation of the transformer is very similar to that of a line, as explained above. If the secondary coil be short-circuited, the E.M.F. on the primary may be adjusted so that the normal full-load current passes through the apparatus. This E.M.F. corresponds very closely to the E.M.F. required for sending current through a short-circuited line, and in ordinary transformers is practically equal to the counter E.M.F., and may be considered equal to it.

A transformer may be taken for experiment in which the E.M.F.'s are 1,000 volts and 100 volts. If five volts, or $\frac{1}{2}$ per cent., is required for sending through the primary a continuous current equal to the normal full-load current of the transformer, and if a similar E.M.F. in the secondary is half a volt, or $\frac{1}{2}$ per cent., then the ohmic loss in the transformer is 1 per cent., and the drop in pressure at the

* Paper read before the National Electric Light Association, Washington.

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secondary terminals between no load and full load will be 1 per cent., if the self-induction be negligible. If, however, there is a self-induction, so that 100 volts, or 10 per cent., is required for sending the normal current through the primary when the secondary is short-circuited, then the drop in pressure is in general greater than 1 per cent., depending principally upon the character of the load. The load may be non-inductive, as lamps, or it may be more or less inductive. The experiments described above, in which a line had the same per cent. ohmic and inductive characteristics as the converter just described, apply to the converter as well as to the line. The drop on such a converter therefore, may vary from 1½ to 10 per cent. when delivering its rated current. Arc lamps or fan motors will produce a very much greater drop than incandescent lamps. The power factor of an alternating-current arc lamp varies considerably, but in a number of cases has been found between 85 and 90 per cent. The drop, when incandescent lamps are replaced by arc lamps on the transformer just described, increases from about 1½ to 5 or 6 per cent.

A secondary line, if it carry a large current, may have a counter E.M.F. of several volts. This may not be enough to increase appreciably the drop in the line between the transformer terminals and incandescent lamps. But the transformer, however, delivers current to the secondary circuit and to the lamps, so that the regulation of the transformer may be affected by the self-induction of the secondary circuit. Cases have occurred in which transformers of a very old type possessing high self-induction were supplying very large secondary currents, and the resulting drop in the transformers was increased several per cent. For example, a circuit of No. 0000 B. & S. wire supplying 100 amperes to 50-volt lamps at a distance of 100ft. has an ohmic drop of 2 per cent. The constant for counter E.M.F. of this circuit, if the wires be 6in. apart, is ·022. The volts at 16,000 alternations are $·022 \times 100 \times ·1 \times 16 = 3·52$, or 7 per cent of 50 volts. The inductive drop in the line corresponding to 7 per cent. is ·25 per cent. The power factor of the aggregate service of the transformer is the second side of a right-angle triangle, of which 7 is one side and 100 is the hypothenuse. This is 90·7, which is the power factor of the total load on the transformer. If the self-induction of the converter be 10 per cent., the inductive drop is 1·2 per cent.; if 20 per cent., the inductive drop is 3·4 per cent., and if 30 per cent., the inductive drop is 7 per cent. The aggregate drop in the converter and secondary circuit in the latter case would be, say, 2 per cent. for ohmic drop in transformer, 2 per cent. ohmic drop in line, 7 per cent. inductive drop in transformer, and ·25 per cent. inductive drop in line, or a total of 11·25 per cent. The necessary ohmic drop is 4 per cent., and the inductive drop resulting from self-induction in transformer and line is therefore 7·25 per cent. If the number of alternations be reduced to 7,200, the inductive drop would be reduced from 7·25 per cent. to 1½ per cent.

Ordinary Tests upon Transformers.

The practical bearing of the self-induction of a transformer upon its regulation and the exact relation between the two does not seem to be clearly recognised, and even Dr. Hopkinson and Dr. Fleming, who have made very exhaustive tests upon transformers, comparing different methods of testing and different types of transformers, have not brought out this point. Attention is given to the exact form of the current wave, and measurements upon the iron losses are attempted within very close limits of error. Their measurements upon the regulation of the same transformer, however, vary from 2 per cent. to 2·4 per cent., or one measurement is one-fifth greater than the other. The presence of slight induction in the secondary load would have caused a very considerable increase, and it is probable that the difference in the measurements made were due to difference in the self-induction in the instruments used, or in the load at the time the tests were made. No note is made of the effect of the self-induction of the load upon regulation, although regulation is one of the most vital points in the practical use of transformers. Even the temperature at which the drop was measured is not stated, although the resistance of a transformer, when continuously working, may be 20 per cent. greater than when cold. The elements of practical importance in a transformer are (1) the iron loss in respect to the efficiency; (2) the regulation in respect to the satisfaction of service; and (3) the temperature to which the insulation is subjected, as affecting the life of the transformer. In the ordinary tests by theoretical men, the iron loss is measured to a very high degree of refinement, although the iron loss in transformers is the one thing which cannot be controlled, and is certain to vary 10 or 15 per cent. in commercial manufacture of transformers of the same size. The wave form of E.M.F. on different dynamos, or the difference in form under different conditions of load on a circuit, may make the loss under different commercial conditions vary several per cent. This renders more refined measurements of no practical use, unless the conditions are stated. The temperature of the iron also affects the loss. The full-load efficiency is usually given as if it had a great deal of importance, whereas the losses in copper during 24 hours ordinarily amount to but a trifling per cent. of the total losses. The regulation, and the temperature to which the insulation is subjected, and which it is able to stand, are generally not mentioned in reports of tests. The usual investigations, and the papers published on the alternating-current transformers, may, perhaps, accurately express many facts in complicated formulæ, but the practical bearing of these points in every-day working seems to be totally ignored.

Mutual Induction.

If two circuits be run on the same pole line they act as a transformer in which one circuit carrying current may act as a primary, and induce E.M.F. in the other as a secondary. If the latter circuit is connected with the same dynamo, and is delivering current, its E.M.F. will be slightly raised or slightly lowered by the effects of the first circuit.

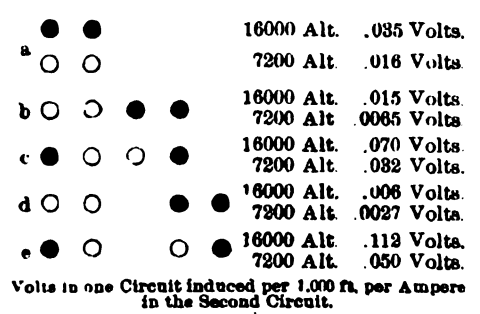

Fig. 13.

Conversely, the second circuit will have similar effect upon its neighbour, raising or lowering its pressure by a slight amount. If the two circuits be connected to different dynamos which are running at slightly different speeds, then the E.M.F. induced by one circuit upon the other will sometimes increase, and at other times decrease the E.M.F. of the circuit, depending upon whether the two currents at a given moment are flowing in the same or in opposite directions. This fluctuation may cause variations in the intensity of the lights supplied. It is readily detected in the service of some central stations, and is, of course, most marked at times of full load, as the induction of one circuit upon another depends upon the strength of the current carried. The fluctuation due to this action may be readily distinguished from that due to slipping of belts or irregularity in engine speed, as the induction effect is due to the difference in alternations between two machines, and the speeds of the two machines are apt to vary slightly from time to time, giving a gradual variation in the rate of fluctuation of the lamps. The fluctuation due to mutual induction of lines occurs only at the end of the line, and is not observed in the station, while the other causes affect the station lights also. The number of volts E.M.F. set up in one circuit by a parallel circuit depends upon the current, the distance which the lines are parallel, and upon the relative positions of the four conductors. The distance between wires may be 6in. or 6ft. without affecting the mutual induction, provided the relative positions be unchanged. Several dispositions of circuits are shown in the accompanying figures, and the number of volts per thousand feet at 7,200 and at 16,000 alternations which are induced in either circuit by one ampere in the

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other are given in connection with each figure. The number of volts required for producing objectionable flickering in the light depends upon the voltage of the lamps in service, the efficiency at which they are run, and the general surroundings in which they are placed, notably the relation of lamps to reflectors, white walls, etc., and the general disposition of the customer.

An E.M.F. of $\frac{1}{2}$ per cent. induced in one circuit by another can in some cases be detected, and usually more than 1 or 2 per cent. will cause objectionable flickering.

Methods of Reducing Mutual Induction and Self-Induction.

The mutual induction is reduced by bringing the wires in each circuit close together and separating the circuits. The effect of this mutual induction may be neutralised by crossing one of the lines at its middle point, so that induction in the first half of the line is counteracted by the induction in the second half. It is readily noted that the effect of self-induction in a circuit is reduced as the wires are brought close together, or if each conductor be divided into several wires in multiple and separated. The effect of self-induction is diminished as the number of alternations is reduced. The following points are also to be noted in connection with inductive drop. If the power factor be nearly 100 per cent., the inductive drop increases as the square of the counter E.M.F. If the E.M.F. of the circuit be increased, and the same power delivered over the same circuit, the per cent. counter E.M.F. decreases as the square of the E.M.F. delivered, and the inductive drop decreases approximately as the fourth power. If the number of alternations be decreased the counter E.M.F. decreases directly, and the inductive drop decreases as the square. The inductive drop at 7,200 alternations is less than one-fourth of that for 16,000 alternations for ordinary power factors.

Capacity in Lines.

The static capacity in ordinary lines is usually small, and its effect is not of importance unless the line be very long or the pressure be very high. The general effect of capacity in the line, or of connecting condensers to the line, is to lessen the current from the generator which is required for supplying inductive load and to reduce the drop due to self-induction. The use of condensers for this purpose may lead to very considerable gains in circuits where the self-induction of line or of load becomes considerable. If an inductive circuit or transformer supply current to condensers, the E.M.F. may increase instead of decreasing, as it does with inductive load.

Polyphase Circuits.

The subjects which have so far been considered apply to single-phase as well as polyphase circuits. The effects of self-induction will be brought to the attention of the electrical engineer much more prominently in connection with polyphase work, however, because larger alternating-current enterprises will be carried out with the polyphase system and power work involving variable power factors will be a large element in this system. There are, in addition, several problems which relate distinctively to polyphase working. One of these is the most suitable number of phases to be used. The two-phase system and the three phase system are both in operation, and while it is admitted by the adherents of each system that there is no fundamental difference between them, yet each has specific characteristics giving particular advantages.

(To be continued.)

A UNIVERSAL SHUNT-BOX FOR GALVANOMETERS.

In our last issue we reproduced the paper read before the Institution of Electrical Engineers on "A Universal Shunt-box for Galvanometers," by Prof. W. E. Ayrton and Mr. T. Mather. Prof. Ayrton now writes to make certain additions.

At the end of the first or opening paragraph, after the words "had been increased," add the following: "by an amount which depended on the details of the construction of the particular galvanometer, and on the adjustment of the controlling magnet."

The following additions are to be made at the end of the paper:

It is well known that with the ordinary method of constructing shunts the resistance of the circuit is altered when the shunt is varied. An interesting question therefore arises whether this change in the resistance of the circuit is greater with the method that we have proposed of constructing a shunt or with the ordinary method. With the ordinary method of keeping the main

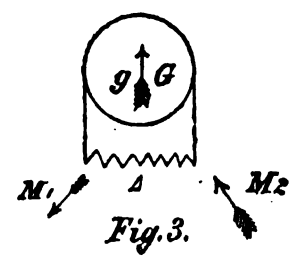

Fig. 3.

leads, M_1, M_2 (Fig. 3) permanently connected with the galvanometer, G, and of varying the current through the galvanometer by altering the resistance, s, of the shunt, the change that is produced in the resistance of the circuit on applying this shunt is, as well known, *from* g to $\frac{s\,g}{s+g}$—that is, the resistance is diminished *by* $\frac{g^2}{s+g}$. If, then, the shunt be such as to allow $\frac{1}{n}$th of the current to pass through the galvanometer, s equals $\frac{g}{n-1}$, and the resistance in circuit is diminished by $\frac{n-1}{n} \times g$ when this shunt is applied. For example, if n be 10, the resistance of the circuit will be diminished by nine-tenths of g.

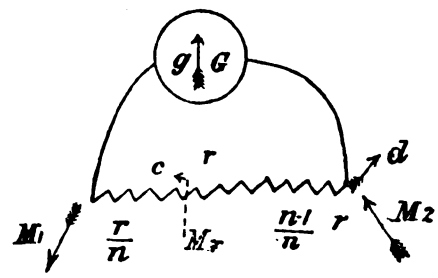

Fig. 4.

With our proposed method of keeping a *fixed* resistance, r, attached to the galvanometer, G (Fig. 4), and of varying the current through the galvanometer by varying the connection of one of the main wires—for example, by moving the main wire, M_2, from the point d to the point c—the resistance of the circuit is altered *from* $\frac{r\,g}{r+g}$ to $\frac{r}{n}\left(\frac{\binom{n-1}{n}\,r+g}{r+g}\right)$—that is, the resistance in the circuit is diminished *by*

$$\frac{1}{r+g}\left\{\frac{n-1}{n}\cdot r\,g-\frac{n-1}{n^2}\,r^2\right\} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Now, this expression depends not merely on the values of n and g, but also on the value of r. If r is selected so as to be less than $n\,g$, the expression (1) is positive—that is, the resistance of the circuit is *lessened* by shifting the main M_2 from the point d to the point c; whereas if r is selected so as to be greater than $n\,g$, the expression (1) is negative, which means that shifting the main M_2 *increases* the resistance of the circuit. Lastly, if r be chosen so as to be exactly equal to $n\,g$, shifting the main produces *no change whatever* in the resistance of the circuit, so that the current *now* passing through the galvanometer after shifting M_2 is exactly $\frac{1}{n}$th of the current that *previously* passed through the galvanometer, for the current in the main circuit undergoes no change, whether the resistance of the circuit be large or small.

By selecting r, then, so that it is roughly equal to $n\,g$, our proposed arrangement gives the following result on shifting the main M_2 from d to c:

(*a*) If the resistance of the rest of the circuit be large compared with that of the galvanometer, the current that *now* passes through the galvanometer is exactly $\frac{1}{n}$th of that which *previously* passed, whatever be the temperature.

(*b*) If the resistance of the rest of the circuit be even small compared with that of the galvanometer, the current that *now* passes through the galvanometer is very nearly $\frac{1}{n}$th of that which *previously* passed, whatever be the temperature.

Contrasted with this, we have, with the ordinary method of applying a shunt, the result:

(*a*) Even if the resistance of the rest of the circuit be large compared with that of the galvanometer, it is only when the tempera-

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ture has one definite value that the current that *now* passes through the galvanometer is exactly $\frac{1}{n}$th of the current that *previously* passed.

(*b*) If the resistance of the rest of the circuit be small compared with that of the galvanometer, the current that *now* passes through the galvanometer is far greater than $\frac{1}{n}$th of the current that *previously* passed.

Lastly, whatever be the values of g, r, and n, our method of altering the current through the galvanometer produces less change in the resistance of the circuit than the ordinary method. For, as already seen, with the ordinary method of applying a shunt the resistance of the circuit is diminished by $\frac{n-1}{n}g$, while on moving the main M_2 from d to c with our method, the resistance of the circuit is diminished by

$$\frac{1}{r+g}\left(\frac{n-1}{n}rg - \frac{n-1}{n^2}r^2\right);$$

therefore the ordinary diminution of resistance minus the diminution of resistance in our case equals the difference between these expressions, which is

$$\frac{(n-1)(ng^2+r^2)}{n^2(r+g)} \quad \ldots\ldots\ldots \quad (2)$$

Now this expression (2) is always positive when n is greater than unity: therefore our method of shunting produces the *less* change in the resistance of the circuit in all cases.

THE HERMITE PROCESS OF TREATING SEWAGE BY ELECTROLYSED SEA-WATER.

REPORT OF THE MEDICAL OFFICER OF HEALTH OF WORTHING.

We reproduce below the report prepared by Mr. C. Kelly, M.D., the medical officer of health for the borough of Worthing, on the Hermite system of treating sewage as experimentally tested at Worthing. The report has been presented to the Sanitary Committee of the Town Council:

In accordance with your request, I have examined carefully the process which has lately been carried out in Worthing for the treatment of sewage by M. Hermite. After having made numerous experiments, and having obtained the assistance of Dr. Klein, F.R.S., and Dr. Dupré, F.R.S., for a bacteriological and chemical enquiry, I now submit to you the following report:

The whole of the plant has been erected under the direction of M. Hermite, and the method adopted is that carried out by the inventor himself, so that this report does not deal with the treatment of sewage at the outfall, nor with the mixed sewage of a town, but only with such sewage as the author of the process has seen fit to include.

The Hermite solution is obtained by the partial electrolysis of sea-water. Two galvanised iron tanks, each capable of holding 1,000 litres, or 220 gallons, are placed side by side, while between and above them an electrolyser is placed in a small metal box. There are four rows of vertical rods, covered in their lower half by a mesh of fine platinum wire, which dip into the sea-water contained in the box; each row contains 11 such rods. Between these rows circular discs of zinc revolve when the machinery is in motion. The current, generated by a dynamo which is driven by a portable steam-engine, passes through the sea-water between the electrodes of zinc and platinum, and in doing so it is said to decompose the magnesium chloride, and so to produce a disinfecting fluid.

A gallon of ordinary sea-water contains about 2,275 grains of combined chlorides in solution, of which magnesium chloride amounts to about 256 grains, the rest being nearly all sodium chloride. It is stated that the magnesium chloride is alone decomposed, and that the sodium chloride serves as a conductor. It takes about 2 to 2½ hours to convert 220 gallons (1,000 litres) into a disinfecting fluid of a strength equal to 0·75 gramme of chlorine per litre, but M. Hermite says that a solution containing 0·30 gramme of chlorine per litre is sufficient for his system. No account is given of the chemical nature of the substance produced by his process; it is said to be an oxygenated compound of chlorine, but no chemical formula is given. The solution has a smell of a weak solution of bleaching powder, and M. Hermite contends that his solution is of a similar nature, with this difference, that magnesia takes the place of lime in a bleaching fluid.

Bleaching fluid is a solution of chlorinated lime, and his solution may then be called chlorinated magnesia. In each case hypochlorous acid seems to be produced in combination with a base, and this acid is one of the compounds of chlorine with oxygen. When good commercial bleaching powder is treated with distilled water, a certain proportion is dissolved, and this fluid will give a strength equal in effect to 25 or 30 grammes of chlorine per litre. Such a liquid gives off a strong smell of hypochlorous acid, and it has active bleaching power when treated with a diluted mineral acid. The strongest Hermite solution which I have examined contained 0·75 gramme of chlorine per litre, or 0·52 grain per imperial gallon. On several occasions the strength was much less, amounting only to 0·22 gramme of chlorine per litre, while in most of the experiments a strength of 0·44 gramme to 0·51 gramme was obtained, or a quantity in excess of that (0·30 gramme) which it is claimed will suffice for disinfection.

The strength of this standard may be better understood when I say that it is 60 times weaker than a saturated solution of good bleaching powder. The Hermite solution loses its strength when kept for a few days, even in closed vessels. Two such samples lost nearly one-twentieth of their strength in two days. The solution contains no free chlorine, as has been often alleged, and it does not redden litmus paper. It will decolourise sulphate of indigo at once, and its strength is thus ascertained: A solution containing a known quantity of arsenious acid is taken, and of this 5 c.c. are placed in a small glass beaker, into which two or three drops of indigo solution are added, so as to give the liquid an intense blue colour. On adding the Hermite solution no change in colour takes place until the arsenious acid is changed into arsenic acid, and when this is completed the blue colour disappears, and the liquid turns to a pale yellow-brown colour. The strength of the solution can thus be quickly ascertained. The weaker the solution the more is required for decolouration. When treated with dilute hydrochloric acid, it gives off chlorine, and it will then bleach reddened litmus paper.

There is no treatment of sewage by electricity as in Webster's method. Electricity is only used to decompose the sea-water, and the altered sea-water so produced is allowed to act chemically on sewage. The process has only been carried on upon a small scale in West-street. In yard A the dynamo and the tanks are placed, and then the electrolysed fluid is pumped up into some store tanks, whence it is distributed for use as occasion may require. In yard B two new water-closets have been recently put up, and these are in direct connection with one of the syphons used in the process. In yard C is a second syphon, also sunk in the ground, which receives the treated sewage from the similar syphon in yard B, and also the ordinary sewage from 14 cottages in West-street. The store tanks in yard A are filled from the dynamo tanks; they are made of galvanised iron, and the water is distributed from them to the flushing-tanks, but not to the sinks of each cottage. There is also a galvanised iron pipe (attached to the public water-main) which leads to one of the store tanks, and thus the tanks can be filled with the town water as well as with the treated sea-water, so that if there were not enough of the latter produced the cottagers would not be without a supply for flushing purposes. It would, indeed, be well worth while to cease using the electrolysed sea-water for a time, and to see what would be the effect of sending through the temporary system (1) sea-water and (2) town water for a period of seven days each. No further arrangements would be required, and it would be interesting to note what difference would be met with when the three methods were compared.

There is a difference in the arrangement in the two yards B and C. In yard B there are two new water-closets erected, each provided with a short hopper basin and trap delivering into a short and partly open drain, which leads directly to the syphon. Each closet has a flushing-tank which holds from two to three gallons, and which is supplied directly from the store tanks in yard A. No storm water nor subsoil water nor any dirty house water can pass down this drain, and the syphon only receives such material—liquid or solid—which has passed through the closets. There is, however, a tap in this yard which is supplied from the store tanks, and whence water can flow at once into the temporary drain, and so into the syphon without going through the closets. The syphon in yard B acts as an intercepting trap whereby anything smaller than the meshes of the cage can pass away into the sewer. It is clear that since any solid matters are, as a rule, broken up on or before their arrival at the syphon, they will pass on at once to the sewer with each successive flush, or whenever there is a current of water issuing from the tap. After a closet has been in use, the next flush will allow a certain amount of fresh fluid to enter at the top of the syphon, which then cause a similar amount of the contents to be displaced and flow forward towards the sewer. If this process be repeated a few times, without any more excreta passing from the closets, the original fluid will be all driven forwards, and the syphon will then be full of water only. It matters not how often these closets are used, for if after such use sufficient clean water passes down the drain, the syphon will soon be filled with this clean water, and any samples taken from the small drum beyond the syphon bend will be samples of clear water only; and if the electrolysed fluid be used, the samples will be those of electrolysed fluid only. The only solid matters left in the cage will be portions of papers which are too large to pass through the perforated holes of the cage. At certain times there must be some solid matter, and then the effluent is more or less tinted.

The case is different with regard to the arrangements in yard C. Here not only the closets but the dirty house water from 14 cottages, as well as the treated sewage from yard B, is constantly passing into the syphon. There is also a considerable amount of storm water, which flows from the roofs and yards of the houses when there is wet weather. The amount of sewage will be very small at night time, but during working hours, and especially on washing days, a large amount of dirty water must constantly be running from the houses away to the sewer. One can tell roughly the nature of the fluid by its appearance before it enters the syphon; sometimes it is clear and almost free from house refuse, as when there is a rainfall, and the closets and house drains do not happen to be used. At other times the fluid has the usual appearance of ordinary liquid house refuse. There is no separate tap here by which a quantity of water can be sent down from the store tanks; each closet is supplied by a flushing-tank, which is fed from the store tanks. Nevertheless, the town water being

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laid on to the interior of each house, the water from the sinks and the water used for washing and cooking is free from the disinfecting fluid until it enters the drains. Any sample taken from the small drum in yard C during working hours will be sure to contain some sewage of greater or less strength. Any samples taken from the small drum or the cylinder in yard C will furnish a better proof of the efficacy of the Hermite process than samples taken in yard B, where it is possible that nothing else than the disinfecting fluid may be drawn.

When 20oz. of fresh excreta—*i.e.*, 4oz solid and 16oz. liquid—were placed in a gallon of Hermite solution there was no bleaching and no breaking up nor destruction of the solid matter; the only effect was to conceal the odour of the contents, and to delay decomposition. When to 20oz. of this treated mixture three times the amount, or 60oz., of Hermite solution were added, there was still no bleaching nor decomposition, but simply dilution of the original mixture, and the contents were partly deodorised. The Hermite solution used was of the strength indicated by 0·61 gramme of chlorine per litre. Dilution with sea-water only produced results similar to those met with when the electrolysed fluid was used, but in the latter case the colour was not so intense. Both fluids prevented the decomposition of the excreta, and the Hermite solution produced in addition a small amount of bleaching effect, When the proportion of excreta was 1 in 32 of the Hermite solution its presence was easily detected, but when a solution of chlorinated lime of similar strength was used better results were obtained, and there was complete discolouration. When strong chlorinated lime solution was tried the contents were decomposed with evolution of froth, the fluid was bleached, and the liquid soon separated on standing into a clear portion and an abundant white flocculent deposit. The change with the Hermite solution was one of dilution chiefly, and not decomposition; the resulting fluid never became clear, and there was no white flocculent precipitate. With weaker solutions obtained from the process, the results were much the same as when sea-water only was used. When dirty house water was taken from yard C, after passing through the syphon, it was nearly as foul as before entering, but any solid matters were, of course, retained when they were not small enough to pass through the holes in the cage; the perforated cage on the house side of the syphon acted simply as a coarse strainer. When to this treated effluent varying portions of Hermite solution were added, the chief effect again was one of dilution only, and there was but little trace of any bleaching action. In the proportion of 1 of this sewage to 10 of the disinfecting fluid the resultant was still foul. Strong chlorinated solution at once produced decomposition, followed by clearing up of the fluid and abundant flocculent precipitate.

I have tried several experiments with a view to see what effect the electrolysed fluid would have when various materials were exposed to its action for several days or weeks. To make a proper comparison three sets of bottles—each holding one pint—were filled with different liquids. In series A ordinary sea-water was used, the water being allowed to stand for a few hours, so as to allow of any sand or suspended matter to settle, and then the clear liquid was poured into each bottle. In series B a saturated solution of chlorinated lime was taken, and after subsidence the clear fluid was used to fill each bottle. In series C a similar set of bottles was filled with freshly-prepared electrolysed liquid of known strength.

It was necessary to make these three sets of experiments, so as to see what action was due to the sea-water acting alone and what was due to it after it had been treated. Since chlorinated lime water is analogous in composition to the electrolysed water, it was used to see what action it would have on the ordinary substances used in sanitary apparatus. Although very much stronger in its action than any Hermite solution, it served as a guide to point out what materials would be most affected, or what substances would resist attack. It is clear that if the stronger solution did not affect any articles which were placed in it, and which were exposed to its action for many weeks, it might fairly be assumed that they would still more easily resist the disinfecting fluid. If, on the other hand, any articles were injured or corroded by the chlorinated lime water, it would be equally fair to assume that the Hermite solution would act in a similar, but less severe, manner. The amount of harm done would in a given time be, of course, greater when the strong solution was employed, but the injury done would be chiefly a matter of time. A substance exposed to the action of the electrolysed fluid for several months might be as much injured as one exposed to the lime solution for a few days.

All the experiments were carried on under similar conditions, but all the solutions were in a state of rest. In this point they differed from what would occur in actual practice, where the fluid is constantly changing, and any rust or corroded particles could be carried away in the current and escape notice. To allow for this loss, the bottles, at intervals of a week, were partly emptied, any clear fluid was poured off, and they were refilled from the original solutions or from solutions of a precisely similar nature freshly obtained. The list given in Table A shows that on the first nine substances the three fluids had no effect. On metallic bodies, as iron and copper, the effect was very marked, but lead, zinc, and tin showed no appreciable difference.

Since iron was the metal most liable to injury, a further trial was made. Three short pieces of 1in. black iron pipe, and three short pieces of 1in. galvanised iron pipe were taken, and each piece was separately marked and carefully weighed. Four pieces (two of each kind) were then placed in chlorinated lime solution and electrolysed fluid, and the remaining two pieces (one of each kind) were set aside for comparison. The four pieces were kept in the solutions, in four separate bottles, for 19 days, when they were taken out, dried, and re-weighed.

TABLE A.

Material.	Sea-water.	Chlorinated lime solution.	Hermite solution.
Mortar	No effect.	Split into layers.	Slight flaking.
Neat cement	No effect.	No effect.	No effect.
Cement	No effect.	No effect.	No effect.
Clay	No effect, beyond crumbling.	No effect, beyond crumbling.	No effect, beyond crumbling.
Paper	No effect; no bleaching of ink on printed paper	No effect; no bleaching of ink on printed paper	No effect; no bleaching of ink on printed paper.
Indiarubber	No effect.	No effect.	No effect.
Insertion (2 ply)	No effect.	No effect.	No effect.
Water-dressed leather	No effect.	Softened.	Softened.
Oil-dressed leather:			
1. Dyed	Solution coloured brown.	Solution coloured brown.	Solution colo'red brown.
2. Thin harness	No other effect.	No other effect, beyond a white deposit on the surface of the material.	No other effect.
Copper (thick wire)	Pale sea-green precipitate and deposit on metal.	Much dark lake precipitate and deposit on metal.	Blue-green precipitate and deposit on metal.
Black iron ...	Dark-brown green deposit.	Copious formation and deposit of rust; much destruction of metal.	Abundant formation and deposit of rust with destruction of metal.
Galvanised iron	No marked change.	Slight erosion of surface and loss of zinc coating.	No marked change.
Zinc	No effect.	Slight erosion.	No change.
Tin.....	No effect.	No effect.	No effect.
Brass fittings.	Same as copper.	Same as copper.	Same as copper.

	Chlorinated Lime Solution.	Hermite Solution.
Black iron 1in. pipe.	*Marked IV.* Original weight =93·5374 grammes. Final weight =89 9048 grammes. Loss=3 6290 grammes, or 56 grains.	*Marked V.* Original weight =97·7494 grammes. Final weight =97·2310 grammes. Loss= 5184 grammes, or 8 grains.
Galvanised iron 1in. pipe.	*Marked I.* Original weight =87·2517 grammes. Final weight =81·3647 grammes. Loss=5·8870 grammes, or 91 grains.	*Marked II.* Original weight =94·1207 grammes. Final weight =94·1855 grammes. Gain=·0648 gramme, or 1 grain.

The slight gain in the last case was due to a little white deposit which adhered strongly to the surface of the galvanised iron. I have not gone into the question of cost, as that is a matter for engineers; nor into the question of trying the process on sewage when it has passed into the sewers, nor upon sewage at the outfall, since the present experiments have only been applied to houses. Besides the annual cost of producing sufficient fluid, there would be a very great outlay in putting down a fresh set of mains, pipes, and cisterns so as to convey it to each house. Moreover, each house, or each group of small houses, would require to be furnished with a syphon. In addition, I give the results which have been obtained from chemical and bacteriological analysis. The samples were taken on the day when M. Hermite explained his system on his recent visit to the town.

Chemical Analysis.

Three samples, collected on February 26, 1894, were sent to Dr. Dupré, F.R.S., of Westminster Hospital. They were from the following sources: (1) M. Hermite's solution, taken in yard A; (2) sea-water; (3) sewage effluent in yard C, after treatment with the electrolysed fluid. Each sample was sent in a Winchester quart bottle, sealed and stoppered. Dr. Dupré, in his report dated March 9, 1894, states as follows: "(1) M. Hermite's solution.—The water contains a small proportion of hypochlorite, probably magnesium or sodium, equal in effect to 0·72 gramme of chlorine per litre, or 50·4 grains per imperial gallon. The sample contained 1,315 grains of combined chlorine, equal to 2,167 grains of chloride of sodium per gallon. (2) Sea-water.—The sample of untreated sea-water sent contains no hypochlorite or free chlorine, and 1,315 grains of combined chlorine per gallon, which is about the normal amount in pure sea-water. The sewage is of dark-brown colour, and very turbid; it has no offensive sewage smell, but has a somewhat disagreeable beery smell. It still contains a small amount of hypochlorite. The amount of oxygen absorbed is extremely high, about four times as much as in the case of ordinary London sewage. The proportion of free ammonia is low for a sewage, but this may, however, be due to its being fresh. The amount of albumenoid ammonia yielded is extremely high. The sample of sewage is evidently of somewhat abnormal character, and does not seem very well suited

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for experimental purposes. Without a direct comparison between the treated and untreated sewage, it is impossible to say what improvement the treatment has effected. I may say, however, that this sample does not smell like ordinary sewage, and has not developed an offensive sewage smell after a week's keeping. Judging from the amount of combined chlorine present, compared with that of sea-water, either a far smaller proportion of sea-water has been used for flushing than water in the case of ordinary water-closets, or else the sewage is otherwise mixed with much water."

ANALYTICAL DETAILS.

Appearance	Turbid, filthy looking.
Colour	Dark brown.
Smell	Not offensive, but somewhat beery smell.
Deposit	Much foul.
Nitrous acid	—
Phosphoric acid	—
Oxygen absorbed from permanganate.	20·3 grains per gallon.
Total dry residue	1,264·0 grains per gallon.
Colour of residue.....	Dark brown.
Behaviour of residue on ignition.	Much charring, evolves slight smell of urine and nitrogenous matter, also that of residue from beer.
Chlorine.....	538 0 grains per gallon.
Ammonia	·931 ,, ,,
Albumenoid ammonia...	2·45 ,, ,,
Hypochlorite equal to free chlorine.	0·026 ,, ,,

BACTERIOLOGICAL ANALYSIS.

Three samples, collected on February 26, 1894, were sent to Dr. Klein, F.R.S., of St. Bartholomew's Hospital. They were from the following sources: (A) Sewage effluent in yard C, after treatment with the electrolysed fluid; (B) sea-water; (C) M. Hermite's solution taken in yard A. Each sample was sent in a Winchester quart bottle, sealed and stoppered.

Dr. Klein, in his report dated March 5, 1894, states that "Sample A was a very turbid fluid, with a large amount of flocculent matter suspended in it; it had no offensive smell. Sample C was clear, and had a strong chlorine smell. Cultivations were at once made from the three samples: "Sample A.—(1) One plate was made with 1·0 c.c., and one plate with 0·1 c.c. of the fluid. (2) 500 c.c. were driven through a Berkefeld filter. This fluid took, owing to the very large amount of solid matter suspended in it, nearly an hour to pass through the filter; the same quantity of water would, as a rule, take about 10 minutes. The particulate matter of the outside of the filter was then brushed off, suspended in 10 c.c. of sterile water, and with 1 c.c. of this each of two gelatine tubes were charged and used for plate cultivation. Result: In both the plates of series 1—*i.e.*, charged with 0·1 c.c. and 1·0 c.c. of original fluid A—numbers of colonies of bacteria developed: an estimation of their number showed that fluid A contained per 1 c.c. between 800 and 1,000 living microbes. From the various colonies of these plates the following species have been isolated: (*a*) bacillus coli, very numerous, (*b*) bacillus subtillis, (*c*) proteus vulgaris, (*d*) bacillus ulna, (*e*) bacillus mesentericus, (*f*) a non-motile cylindrical bacillus, not liquefying, (*g*) various species of cocci. It follows from this that of the species that developed, several are such as do not form spores—*e.g.*, bacillus coli, proteus vulgaris, and the several species of cocci.

"In the plates of series 2—that is, those which each received the solid matter of 50 c.c. of the original fluid—the number of colonies that came up in 48 hours was so great, and the liquefaction so extensive, that they were practically useless for counting them or determining their character. Now this sample A, as far as I understand the description given on the label and in your letter, was sewage that had been subjected to the treatment after M. Hermite's process. Ordinary raw sewage of London, Manchester, and other towns that I have examined, contains between three millions and 10 millions of bacteria per c.c.; this 'treated' sewage effluent of Worthing, as stated above, contains only 800 to 1,000 microbes per 1 c.c.; it follows that there has been effected by the admixture of the Hermite solution a remarkable reduction in the number of living microbes, but it also follows that nothing like sterilisation has been produced, since a considerable number of bacteria have survived the process; and be it also noted that amongst those that survived are several species that do not form spores, so that an assertion to the effect that the highly-resisting spores are not killed, whereas non-sporing bacilli are killed by the process, is not borne out by these observations.

"A further experiment was made with this sample A on March 3—*i.e.*, after it had been kept four days. With ½ c.c. of the fluid A, a gelatine plate was made and the result watched. On the third and fourth day the number of colonies were counted, and as a result it was found that their number had increased meanwhile more than fourfold. Cultivations made after six days' keeping showed that the number of microbes had meanwhile increased more than one hundredfold. Sample B: A plate was made with 1 c.c. of this sea-water. The number of colonies that came up was too great to be counted; in fact, the gelatine was densely pervaded by colonies. A plate was made with 0·01 c.c. of the water, having been kept for two days. The number of colonies was estimated to be 1,000 per 1 c.c. Sample C was treated in the same manner as sample A. Result: The fluid proved sterile, only two colonies were noticed in one plate made with the particulate matter of 100 c.c. of the sample; the companion plate was free of any growth. Now, this result is extremely interesting, for it proves that sea-water containing a very large number of living microbes (sample B) becomes practically sterilised by the Hermite process (sample C).

"In order to ascertain further whether cultures of non-sporing bacilli when mixed with Hermite's solution become sterilised thereby, I made the following experiments; but I should repeat here that I had no great hopes after the results obtained with sample A, for we have seen that this sample was not anything like sterile, still containing 800 to 1,000 microbes per 1 c.c. Broth cultures of (1) bacillus coli, (2) bacillus of typhoid, and (3) cholera vibrios were mixed each with the same bulk of Hermite solution (C), and after thoroughly shaking were left standing for 20 minutes, and from them sub-cultures were made in normal nutritive media, in broth and in gelatine, each culture tube receiving one drop of the mixture. The result was this: All sub-cultures in broth showed growth, the broth cultures were uniformly turbid, in 24 hours incubated at 37deg. C.; the gelatine tubes of the bacillus coli and the cholera vibrio incubated at 20deg. C., showed numerous colonies after 48 hours, those of the typhoid developed a small number of colonies after four days. This is quite in harmony with the experience repeatedly made—viz., after allowing the disinfectant to act on the microbes, it is necessary to expose the sub-cultures made from the 'treated' material to 37deg. C., in order to avoid a hasty conclusion; repeatedly it has been found that while sub-cultures exposed to 20deg. C. failed to give a positive result in two days, those exposed to 37deg. C. yielded good growth. The growth which appeared in these different sub-cultures in broth was tested by further sub-cultures, and thereby it was ascertained that the same microbes that were used for the initial experiment were recovered in their perfectly normal characters. There is one point in connection with this series of experiments which is of importance, and that is—that by the addition of the same bulk of Hermite solution to the original normal cultures the number of living microbes had decidedly become reduced, although a good many living examples were still left. This was determined in the following manner: From the original normal cultures 1, 2, and 3, a definite quantity was withdrawn, mixed with the same bulk of sterile salt solution, and from this mixture plates in Agar were made and incubated at 37deg. C., in order to determine the number of microbes per 1 c.c. After the treatment of the original cultures with the same bulk of Hermite solution for 20 minutes, similar plates were made and the number of colonies coming up in these plates was compared with those of the previous control plates. It was found that by the Hermite solution the number of living microbes was reduced something like over 100 times.

"A further experiment was made with these broth cultures of colon, typhoid, and cholera, to which an equal bulk of Hermite solution had been added. It was this. After keeping the mixture for 24 hours, inoculation was made into fresh sterile broth, each tube receiving about five drops of the 'treated' culture. The result was interesting. The bacillus coli and cholera vibrio yielded normal growth; the typhoid did not yield any growth; so that even after 24 hours' exposure of broth culture of bacillus coli and of cholera vibrio to an equal bulk of Hermite's solution, each five drops of the coli fluid and the cholera fluid still contained living microbes, while the typhoid fluid appeared sterile.

"Now, it is maintained by the 'Hermite system,' as explained in the printed leaflet which you kindly sent me, that 'fæcal matter is instantaneously destroyed (meaning, of course, sterilised) when mixed with the electrolysed disinfecting liquid.' The above experiments show that this was not the case with the sewage operated upon at Worthing, nor was it the case when cultures of bacillus coli, bacillus of typhoid or of cholera vibrio, were subjected to the liquid. I do not know what is the proportion of Hermite solution that this 'Hermite system' recommends to be added to 'fæcal matter' in order to sterilise it, but it must be quite clear from the above experiments on the broth cultufes that even an equal bulk of Hermite solution added to the cultures does not by any means sterilise them even after 20 minutes' exposure, and some not even after 24 hours. Whether such an addition—*i.e.*, equal bulk—in regard to sewage is possible in practice, is a matter on which I do not wish to give an opinion, but anything equal, or *à fortiori* anything less, would for sterillisation purposes be vain. Of an 'instantaneous' action there is nothing to be noticed in the above experiments."

Since there is no instantaneous decomposition of fæcal matter and no sterilisation of sewage, I am of opinion that the process, as far as the late trials have gone, has therefore failed to produce the results which are claimed for it by its inventor.

THE COMMERCIAL POSITION OF ELECTRIC SUPPLY AND MANUFACTURING COMPANIES.*

It is now about a year ago since we reviewed the position of the electric lighting companies, and pointed out the fair promises for the future which many of them held out. The report of these companies for the past 12 months are now nearly all to hand, and in the vast majority of cases they amply justify the predictions which we ventured to make in the early part of last year. The capital embarked in this new-fangled business, which is mainly the growth of the last five or six years, is increasing annually. The 14 companies operating in London and its suburbs have now between them a paid-up share capital of £3,250,141, in addition to an issued loan capital of £604,600, so that together we have nearly four millions of money

* From the *Financial Times*.

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embarked in the electrical supply business in the Metropolis alone. The provincial companies are generally on a smaller scale, but between them hold a considerable amount of capital; thus the paid-up share capital of 20 provincial companies amounts to £721,030, and the loan capital to £160,484. Then there are the manufacturing companies, nine of which have between them a paid-up share capital of £2,051,654, and have issued loans to the extent of £365,130. Taking all the large companies, supply and manufacturing, together, we find the total paid-up share and loan capital employed by them comes to £7,153,039. This is a respectable amount to have been absorbed in a few years by an entirely new industry, and fresh capital is constantly flowing in the same direction. Many of the provincial companies have not issued more than half or a third of their share capital, and one or two of the London companies are in a similar position, while others, whose share capital is all called up, now and then make a fresh issue of debentures. Not only, therefore, have we already a large financial stake in electricity, but we bid fair to have double or treble the amount in a few years' time. Electric lighting has spread slowly in the United Kingdom compared with its progress in America, and even in parts of the Continent, but our provincial towns are now taking the matter up one after the other, and the present year will probably see a great extension in this direction.

Considering the convenience, healthfulness, and beauty of the electric light, it is extremely satisfactory to find that, as far as can be judged from the history of the companies, it is undoubtedly a commercial success. Subjoined we give a table showing the results given by nine leading London supply companies for the past two years:

London supply companies.	Year ended.	Results as per Reports. Current sold, rents, fees, etc. £	Cost of current, management, etc. £	Profit or loss for year. £
Charing Cross and Strand..	Dec. '92	20,659	10,411	+ 10,248
	,, '93	22,304	13,650	+ 8,654
Chelsea	,, '92	12,523	8,204	+ 4,319
	,, '93	13,732	7,463	+ 6,269
City of London	,, '92	10,426	9,991	+ 435
	,, '93	40,032	23,092	+ 16,940
House to House	,, '92	10,689	7,852	+ 2,837
	,, '93	12,064	7,832	+ 4,231
London	,, '91	15,081	22,091	- 6,958
	,, '92	23,693	27,716	- 3,914
Metropolitan...	,, '91	43,747	34,028	+ 9,719
	,, '92	54,572	40,404	+ 14,168
St. James's and Pall Mall ...	,, '92	34,559	21,100	+ 13,459
	,, '93	21,059	21,149	+ 9,919
Westminster...	,, '92	36,443	24,834	+ 11,609
	,, '93	43,833	28,267	+ 15,566
Kensington ...	,, '92	17,539	10,711	+ 6,828
	,, '93	21,745	12,695	+ 9,050

In all except three of these nine companies we find an increase in profits for last year. In one instance, that of the London Company, which has not yet reached the dividend-paying stage, there is a diminution of nearly 50 per cent. in the amount of loss made. The Charing Cross and Strand and the Westminster Companies show exceptionally a decrease in profits, but this does not necessarily imply retrogression, for in each case there has been considerable additional expenditure on capital account, which has yet to be made productive, although it may be admitted that these companies have not done so well as the others on the list. But, taking the table through, it is fairly evident that there was last year a considerable increase in gross receipts, which, coupled with a diminution in the ratio of expenditure, has produced a most favourable effect upon net revenue. The results shown are the more satisfactory as we know that in one or two instances the companies have reduced the price of their current. That this tendency has not been confined to London alone is proved by the next table appended, showing the progress made by some of the provincial companies, which, generally speaking, are of later date than those of the Metropolis.

Provincial supply companies.	Year ended.	Results as per Reports. Current sold, rents, fees, etc. £	Cost of current, management, etc. £	Profit or loss for year. £
Birmingham ...	Dec. '92	—	—	+ 2,320
	,, '93	—	—	+ 3,124
Bournemouth .	,, '92	3,664	3,337	+ 327
	,, '93	5,222	3,740	+ 1,482
Eastbourne ...	,, '92	4,549	3,203	+ 1,346
	,, '93	5,216	3,235	+ 1,981
Liverpool	,, '92	—	—	+ 10,652
	,, '93	—	—	+ 11,410
Newcastle and District	,, '92	5,916	3,777	+ 2,139
	,, '93	7,221	4,271	+ 2,950
Newcastle-on-Tyne	,, '92	6,213	3,912	+ 2,300
	,, '93	6,753	4,293	+ 2,460
Northampton..	,, '92	1,229	922	+ 307
	,, '93	1,492	956	+ 536

In every one of these instances there is a fair increase on profits. The tendency here exhibited is general, and extends to other companies which are not tabulated on our list. Some companies, such as the Oxford and Hastings, have only been actually supplying current for a year, so that no comparison is possible, but they yet show a fair profit on working. Where the comparison, as in the case of one or two of the London undertakings, can be made for three years, the results obtained are similar.

The manufacturing companies do not exhibit the same progress, owing possibly to the fact that the great demand for the London area has for the time being relaxed. Of the four companies referred to in the annexed table, only one, the Edison and Swan, exhibits an increase in profits for its last fiscal year:

Manufacturing companies.	Year ended.	Results as per Reports. Sales, etc. £	Expend. £	Profit. £
Brush	June, '91	39,916	23,359	16,577
	,, '92	55,451	28,097	27,354
	,, '93	52,556	26,914	25,642
Crompton	March, '91	33,709	20,678	13,031
	,, '92	38,355	23,287	15,068
	,, '93	40,443	28,490	11,953
Edison and Swan	June, '91	146,699	73,794	72,905
	,, '92	152,740	77,927	74,811
	,, '93	195,046	108,403	86,643
Swan United...	Sept. '91	59,942	20,903	39,039
	,, '92	45,432	10,592	34,840
	,, '93	38,475	9,597	28,878

For much of the information conveyed in the above tables we are indebted to some very carefully-compiled statistics made by a well-known firm of Stock Exchange brokers. From an inspection of these statistics we come to the conclusion that the supply companies which display the most promise, as far as can be judged from past results, are the Chelsea, the House-to-House, the Westminster, the Liverpool, the Kensington and Knightsbridge, and possibly the City of London. The too hasty and lavish expenditure of capital is the great danger which has to be guarded against, and in this respect some of the provincial companies set a good example to their London contemporaries. Of the 33 supply companies enumerated in the statistics referred to, 11 have reached the dividend-paying stage, and five out of the 11 have declared their first dividend this year. As a whole, the outlook for the supply companies is distinctly hopeful, always provided that they take care not to rush too fast ahead in the matter of capital expenditure.

KINGSTON-UPON-HULL ELECTRIC LIGHTING ACCOUNTS.

The accounts of the electric lighting department of the Kingston-upon-Hull county borough for the year ending December 31, 1893, have just been issued. The capital expenditure during that year amounted to £21,637, and the total expenditure to December 31, 1893, has reached the sum of £32,818. We give below the revenue account and general balance-sheet:

REVENUE ACCOUNT.

Expenditure.	£ s. d.	£ s. d.
A.—To Generation of Electricity.		
Coal or other fuel, including dues, carriage, unloading, storing, and all expenses of placing the same on the works	£470 19 6	
Oil, waste, water, and engine-room stores	76 1 3	
Wages at generating stations	274 0 6	
Repairs and maintenance, as follows: engines and boilers, £31. 15s. 3d.; other machinery, instruments and tools, £2. 1s. 8d.; accumulators and accessories, £1. 5s. 6d.....	35 2 5	
		856 3 8
B.—To Distribution of Electricity.		
Wages and other remuneration to linesmen, fitters, labourers.....	68 14 5	
Repairs, maintenance, and renewals of mains of all classes, including materials and laying the same	14 10 11	
Repairs, maintenance, and renewals of apparatus at distributing stations	3 12 5	
		86 17 9
E.—Rents, Rates, and Taxes.		
Rents payable	111 19 7	
Rates and taxes	23 10 0	
		135 9 7
F.—Management Expenses.		
Salaries (engineer's department)	335 11 6	
Printing and stationery	103 15 10	
General establishment charges.....	91 4 6	
		530 11 10
G.—To Law and Parliamentary Charges.		
Law expenses		0 5 3
H.—Special Charges.		
Insurance, etc.....		21 12 4
		1,631 0 5
Amount carried to net revenue account		888 2 4
		£2,519 2 9

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Receipts.	£	s.	d.
Sale of current per meter, 7d. per B.T.U.	2,211	0	5
Rental of meters and other apparatus on consumers' premises	41	0	2
Other items, miscellaneous	210	3	2
Stores on hand, December 31, 1893	56	19	0
	£2,519	2	9

Dr. NET REVENUE ACCOUNT.	£	s.	d.
Interest on mortgage debt accrued due to date	875	0	0
Balance carried down	13	2	4
	£888	2	4

Cr.	£	s.	d.
Balance brought from revenue	888	2	4
	£888	2	4

GENERAL BALANCE-SHEET.

Liabilities.		£	s.	d.
Net revenue account—balance at credit thereof		13	2	4
Amount due to treasurer—revenue account to December 31, 1893	£1,509 5 7			
Ditto—capital account, ditto	32,818 14 6			
		34,328	0	1
		£34,341	2	5

Assets.	£	s.	d.
Capital account—amount expended for works	32,677	12	2
By stores on hand at December 31, 1893: coal, £38. 11s. 1d.; oil, waste, etc., £18. 7s. 11d.; general, £141. 2s. 4d.	198	1	4
Sundry debtors for current supplied to December 31, 1893, £1,332. 18s. 7d.; other debtors, £132. 10s. 4d.	1,465	8	11
	£34,341	2	5

COMPANIES' REPORTS.

SOUTHAMPTON ELECTRIC LIGHT AND POWER COMPANY, LIMITED.

Directors: Mr. G. T. Harper, chairman; Mr. W. H. Mitchell; Mr. J. F. Obree, vice-chairman; Mr. G. J. Tilling; Mr. J. F. Albright. Secretary: Mr. J. T. Hamilton.

Report of the directors and statement of accounts for the year ending December 31 last.

The anticipations of your directors of steady and continuous progress in the business of the Company have been realised. The increased revenue amounts to £553. 9s. 10d. over 1892, but a satisfactory feature is that the expenses are practically the same, thus making the whole of the increase net gain.

STATEMENT OF REVENUE AND EXPENSES.

	Lamps (8-c.p.), Dec. 31.	Units sold.	Revenue. £	s.	d.	Expenses. £	s.	d.
1891 (part only)	—	5,469	350	5	11	535	2	1
1892	2,200	35,537	1,153	4	10	1,152	0	4
1893	3,162	53,848	1,606	14	8	1,121	4	8

This statement is doubly gratifying inasmuch as the directors reduced the maximum price of the current to 8d. from January 1, 1893. With the view of placing the Company upon a dividend-paying footing, your directors have resolved to relinquish the fees already debited in the two previous balance-sheets—namely, £400—and to take no fees for the year 1893. After debiting interest on debentures and overdraft and depreciation, a net profit of £170. 1s. 11d. is shown. This sum, together with £400 recredited for directors' fees, reduces the loss brought forward of £754. 19s. 9d. to £184. 17s. 10d. As the sales of current for January and February of this year have shown an increase of 50 per cent. over the corresponding period of the previous year, your directors feel justified in expressing the opinion that they will be able to declare a dividend at their next annual meeting. To enable the directors to cope with the new applications, it is highly essential that more capital should be forthcoming, and in view of the favourable showing of the Company's working, the directors hope for the support of the shareholders in bringing fresh capital into the business. The directors who retire from office are Mr. J. F. Obree and Mr. G. J. Tilling, who, being eligible, offer themselves for re-election. The auditor, Mr. C. Cox, also offers himself for re-election.

BALANCE-SHEET.

	£	s.	d.
Nominal capital, £30,000.			
Subscribed—50 preference shares at £5	250	0	0
708 ordinary shares at £5	3,540	0	0
	3,790	0	0
Less calls unpaid	55	0	0
	3,735	0	0
Debentures	1,150	0	0
Sundry creditors	961	18	7
Bank overdraft	8,440	0	7
Suspense account	141	10	8
	£14,428	9	10

	£	s.	d.
Buildings, less depreciation	594	18	0
Mains, less depreciation	6,578	5	10
Plant, machinery, etc., less depreciation	4,843	3	9
Meters, less depreciation	707	5	0
Electrical instruments, less depreciation	154	7	5
General stores, coal, lamps, oil, etc.	43	5	1
Office furniture	9	12	2
License	421	15	6
Preliminary expenses	284	13	4
Sundry debtors	604	5	11
Cash in hand	2	0	0
Profit and loss account—loss 1891, £384. 16s. 2d.; and loss 1892, £370. 3s. 7d.; less directors' fees, £400; and profit 1893, £170. 1s. 11d.	184	17	10
	£14,428	9	10

PROFIT AND LOSS ACCOUNT.

	£	s.	d.	£	s.	d.
Coal and other fuel	272	4	4			
Oil, waste, water, etc.	54	3	3			
				326	7	7
Wages and salaries at central station				376	5	8
Repairs and maintenance	48	18	3			
Lamps	2	1	5			
				50	19	8
Rent	61	5	0			
Rates and taxes	18	10	6			
Insurances	13	10	3			
				93	5	9
Hire of motor				1	5	11
Salary of secretary	50	0	0			
Commission on collections	35	14	2			
Stationery and printing	21	9	2			
General establishment charges	12	17	7			
Law charges	0	17	2			
				120	18	1
Auditor's fee				2	2	0
Depreciation				150	0	0
Debenture interest	42	11	1			
Bank charges	272	17	0			
				315	8	1
				1,436	12	9
Balance—profit				170	1	11
				£1,606	14	8

	£	s.	d.
Sale of current	1,542	14	10
Meter rent	42	7	10
	1,585	1	10
Connections	21	1	10
Transfer fees, etc.	0	11	0
	£1,606	14	8

COMPANIES' MEETINGS.

BOURNEMOUTH AND DISTRICT ELECTRIC SUPPLY COMPANY, LIMITED.

The third annual general meeting of the shareholders of the above Company was held on Friday last, Mr. Leveson Scarth occupying the chair. The report of the directors was as follows: "The directors beg to submit herewith a statement of accounts for the year ending December 31, 1893. The progress made by the Company during the past year has been very satisfactory. The number of lamps connected was equivalent on December 31, 1892, to 8,988 of 8 c.p.; and on December 31, 1893, to 14,552 of 8 c.p.—showing an increase of 5,564 during the year. At the date of this report the number of lamps connected is equivalent to 15,286 of 8 c.p. Many more are in course of installation, and will shortly be connected to the Company's mains. The accounts now submitted show a profit on the full year's working of £1,481. 10s. 6d., and after providing the sum of £444. 0s. 4d. to pay interest due to end of December last on the £10,000 6 per cent. first mortgage debentures so successfully issued in the spring, £32. 15s. 11d. standing at interest account, and writing off the balance of loss brought forward from 1892 (£34. 3s. 3d.), a net balance of £974. 16s. 9d. profit remains. Of this sum it has been decided to write off £615. 14s. 5d. to depreciation account, leaving a balance of £359. 3s. 4d. available for purposes of dividend. Considerable additions and extensions have been made to the buildings, machinery, plant, and mains, the latter item including the extension of the Company's system to Boscombe, where are supplied the Hotel Burlington (an equivalent of about 1,200 8-c.p. lamps) and the extensive block of buildings comprising the arcade, shops, and Salisbury Hotel, owned by Mr. Beckett. The plant of the lighting station has been found to be fully adequate to the demands made upon it, and on the Saturday before Christmas Day the heaviest load of the whole year (132 amperes) was successfully carried, extra engine and dynamo power being held in reserve sufficient for supplying current to about 3,000 lamps of 8 c.p. in addition. The electric light is finding increased favour throughout the extensive district covered by the Company's

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mains. Fresh applications are continually being received, and the directors look forward with confidence to the result of the present year's working."

The **Chairman**, in the course of his remarks, stated that the business was progressing with reasonable rapidity, and had now reached the stage of being a dividend-earning concern, the directors having decided to recommend the payment out of profits of two-thirds of a 5 per cent. dividend on ordinary shares, the Brush Company paying the remaining one-third under their guarantee, which did not expire till June next. With regard to the items figured in the balance-sheet in respect to preliminary charges and telephone action, and to which the Company's auditors had called attention, the Board recommended that the £500 standing to credit as preliminary expenses be charged to capital account, but that the debenture preliminary expenses and the cost to the Company of the telephone action be dealt with, gradually writing off against revenue account a proportion year by year. The difficulties represented by the large sum cost of telephone action were, the directors hoped, nearly at an end, especially as the telephone company were now adopting the system of complete metallic circuits for their currents, a method which, supplementing the continued efforts of the Company, would obviate all future trouble. The directors had devoted much attention to mains and cables, and were incurring considerable expense in accelerating the policy of laying down concentric cables throughout the system. All the requirements of the Board of Trade were being promptly satisfied, and the directors wished to acknowledge the courtesy with which these necessary works were being facilitated by the Town Council and surveyor. The plant at the central station had been and was still fully adequate to the load, as stated in the report, but the directors anticipated an increase of at least 30 per cent. in the output during the ensuing year, and this would necessitate additional engines and alternators At the same time, they would endeavour to preserve the greatest economy in running expenses. During the last two months Mr. A. J. Lawson, M.I.E.E., London, had been acting as consulting engineer, and the directors, out of a large number of applications, appointed as resident engineer Mr. H. M. Sayers, engineer to the electric lighting company in Oporto. Mr. Sayers would take technical charge of the Company's system from April 20. Mr. Shepherd's connection with the Company, for which he had done much work since its formation, had now terminated. The directors looked forward with confidence to declaring a fair dividend out of the earnings of the Company during the present year.

The motion for the adoption of the report and accounts was seconded and carried.

The retiring directors, Mr. John Fair and Mr. William Fisher, were re-elected, and Messrs. Cridland and Co., the Company's auditors, were reappointed auditors to the Company.

BUSINESS NOTES.

Great Northern Telegraph Company.—For the month of March the receipts were £22,000.

Western and Brazilian Telegraph Company.—The receipts for the week ended March 30 were £2,659.

Sunderland.—The Sunderland Corporation is seeking sanction for a loan of £25,000 for electric lighting works.

Liverpool Overhead Railway.—The traffic receipts of this railway for the week ending 1st inst. amounted to £841.

Portsmouth.—The Corporation have this week invited applications for various positions in connection with the electricity supply station.

Direct Spanish Telegraph Company.—The receipts for the month of March were £215 less than for the corresponding period of 1893.

Cuba Submarine Telegraph Company.—For the month of March the receipts were £75 less than for the corresponding period of 1893.

Tenders for Rhyl.—Tenders are invited for the electric lighting of the Rhyl Pier and Pavilion. Applications to be sent to 3, Bradshaw-street, Shudehill.

Bradford-on-Avon.—The Town Commissioners have decided to consider the subject of electric lighting six weeks hence, and a deputation is to be invited to attend.

Kensington.—Messrs. Drake and Gorham have just been entrusted with the wiring of the two new houses in Melbury-road, Kensington. The number of lights will be 150.

The City of London Court.—The new wing which has been added to the City of London Court was formally opened on Monday. It will shortly be lighted by electricity.

Bath.—At a meeting of the Bath Town Council a proposal to connect the engineer's office by telephone with the works at Bathampton and Monkswood, at a yearly charge of £40 for 10 years, was adopted.

Issue of Debenture Stock.—The whole of the £30,000 4 per cent. debenture stock recently issued by the St. James's and Pall Mall Electric Light Company, Limited, has been applied for and allotted.

Personal.—The appointment of Mr. George G. Clark as second engineer in connection with the electric lighting station of the Aberdeen Town Council, for the period of six months, has been confirmed.

Eastern Telegraph Company.—The receipts for the month of March were £57,677, as against £55,786 for the corresponding period of 1893.

Direct United States Cable Company.—The Board have resolved to pay an interim dividend of 2s. per share, free of tax, being at the rate of 2 per cent. per annum, for the quarter ending March 31.

Globe Telegraph and Trust Company.—The directors have declared an interim dividend of 3s. per share, on the preference shares, less tax, and 2s. 6d. on the ordinary, from which the tax has already been deducted.

Dewsbury.—The Dewsbury Board of Guardians have decided to erect the buildings and plant for lighting the workhouse and cottage homes belonging to the union by electricity, and to ask for powers to borrow £2,150 towards the cost, the original estimate of which was £1,400.

Pembroke Dock.—Two dynamos, with which it is intended to light by electricity the ships building at the dockyard, have been ordered, and will be delivered shortly. The dynamos will also supply the current necessary for a new process of drilling which it is proposed to introduce.

City and South London Railway.—The receipts of the Company for the week ending April 1 were £844, against £744 for the same period last year, or an increase of £100. The total receipts for the first half-year of 1894 show an increase of £20 compared with those for the corresponding period of 1893.

Bristol.—At their meeting which was to be held yesterday the Sanitary Committee were to have before them the estimate for the forthcoming half-year, and among the items which do not promise to be less than in the corresponding half of last year is the call from the Electrical Committee. It amounts to something like £4,000.

Forthcoming Lectures at Sheffield.—A course of lectures will be given on April 9 and the two following Mondays, in the Central School, Sheffield, by Mr. T. Scott Anderson, A.M.I.E.E., in which will be covered the various means whereby electric power may be utilised in connection with welding, forging, hardening, tempering etc.

Is there a Market in Siberia?—Andreas Eltischeff, Jekaterinburg, Russia, importer for the Ural and Siberia of technical and electrical machinery, armatures, tools, and instruments for machines of every description, invites manufacturers desirous of introducing their goods to the Ural and Siberia to send him price lists and terms.

Dover.—The engineer and consulting engineer of the Dover Electric Light Company visited Dover last week and arranged for laying down the pipes for containing the mains which will be necessary for supplying public and private lights in Dover. Mr. H. Stiff, the contractor for the buildings, has commenced the erection of the station.

Larne.—At the monthly meeting of the Town Commissioners of Larne the draft contract between the Commissioners and Messrs. J. E. H. Gordon and Co., electrical engineers, for the lighting of the town, was submitted, and, after discussion of some amendments, it was agreed that it be forwarded to London for the approval of the contractors.

Tenders Invited.—The Committee of Visitors of the North Wales Counties Lunatic Asylum invite tenders for the construction and maintenance, for a period of five years, of a telephone between the asylum and Glanywern Hall, a distance of about three miles. Further particulars may be obtained of Mr. Wm. Barker, clerk to the Visitors, the Asylum, Denbigh.

W. T. Henley's Telegraph Works Company, Limited.—Warrants have been posted to the shareholders of this Company for dividends at the rate of 7 per cent. per annum on the preference shares (less income tax) for the half-year ending December 31, 1893, and 5 per cent. per annum on the ordinary shares (free of income tax) for the year ending December 31, 1893.

Llanelly.—The Local Board have received a communication from the Electrical Installation Company (in reply to a communication from the Board) that they hoped to complete the agreement to proceed with the electric lighting of Llanelly in a fortnight's time. The Board on Monday decided that as sufficient time had already be given, the agreement with the company should be terminated.

Newcastle Street-Lighting.—At a meeting of the Newcastle City Lighting Committee, the committee ordered that an electric light of 1,500 c.p. be placed at the corner of Shields-road, and one of 1,500 c.p. to be placed at the corner of the junction of Picton-place and Oxford-street, in New Bridge-street, near the Blyth and Tyne Railway Station, both electric lamps to come into operation on August 28.

Belfast.—A meeting of the Corporation in committee was held last week to consider the appointment of a resident engineer to take charge of the electricity works about to be established. There were, it appears, 59 candidates, and it was arranged that the Electric Lighting Committee should make a selection of half-a-dozen from this number, and submit them for final decision to another meeting of the Council.

Cardiff.—At a meeting of the Cardiff Technical Instruction Committee, held at the South Wales and Monmouthshire University College, Principal Jones stated that the engineering buildings were progressing satisfactorily, and that it had been promised that the workshop would be ready by the end of this month. Provision will be made for the exhibition and use of engines, dynamos, and other machinery.

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Eastern Extension Company's Debentures.—The Eastern Extension, Australasia, and China Telegraph Company, Limited, give notice that various debentures were drawn by lot on April 2, 1894, at the offices of the Company, and that they will be paid off at par on July 2 next at Messrs. Barclay, Bevan, and Co., 54, Lombard-street, E.C.

Eastern Extension, Australasia, and China Telegraph Company.—The accounts of the Eastern Extension, Australasia, and China Telegraph Company to December 31 show, subject to audit, a balance of profit of £189,080 after payment of three interim dividends The directors propose to distribute the usual dividend of 5 per cent. for 1893, together with a bonus of 4s. per share, or 2 per cent., making a total distribution of 7 per cent. for the year.

Medical Battery Company, Limited.—Mr. Warley, deputy official receiver, presided on Tuesday at a meeting of the creditors of the Medical Battery Company, Limited, for the purpose of considering a draft scheme of reconstruction put forward by the debenture-holders, shareholders, and creditors of the Company. At the opening of the proceedings it was ruled that the meeting should be private, and it was stated that the scheme would be made public when complete and approved.

Elmore's Foreign Copper Company. — In the Chancery Division, Mr. Justice Vaughan Williams had before him on Wednesday the petition of General Sir R. J. Meade for the winding up of Elmore's Foreign and Colonial Copper Depositing Company, Limited. Counsel said that the petition came up on the last day of last sitting, and it stood over till now. In the interval the petitioner had died, and the executors had not proved the will, and under these circumstances it was asked that it should stand adjourned for a month. His Lordship assented.

Crystal "Star" Pendant.—Messrs. Faraday and Son have introduced under this title a fitting which is designed as an effective top light in high rooms. It is especially suited to hang to the finials or hammerbeams of large halls and dining-rooms, or in high conservatories. At a height of 12ft. or more, the light is so refracted and transmitted by the cut-glass facets and silvered reflector that it becomes a complete star in appearance, and, since it is placed so far above the line of horizontal vision, the full power of an unscreened electric light is made available without injury or annoyance to the eye.

Aberdeen.—The premises of Mr. George Souter, 45, St. Nicholas-street, have just been equipped with the electric light. The installation has been fitted up by Messrs. Shirras, Laing, and Co., under the superintendence of Mr. J. A. Linney. Incandescent lamps have been used throughout. At a meeting of the Works Committee of Aberdeen Harbour Board a report was submitted by Mr. Smith, engineer, with reference to proposed alterations at Regent Bridge and the erection of a new bridge. Mr. Smith suggests that the bridge should be opened and closed by an electric motor driven off the town mains.

Turret Lathes and Screw Machines.—A catalogue has reached us from Mr. H. F. L. Orcutt, of 145, Cannon-street, E C. (who represents in this country Messrs. L. Loewe and Co., of Berlin), concerning the company's turret lathes and screw machines. Those referred to in the list are the company's standard types of turret lathes and screw machines. Special attention is directed to one class of automatic screw machine, which makes screws or formed parts from the rod of either brass, iron, or steel, and from square, hexagon, or round stock. This machine is easily operated, and by improved mechanism the loss of time between the various operations is reduced to a minimum.

Telephone Company of Egypt.—The eleventh ordinary general meeting of this Company was held on Tuesday at the offices, 14, Austinfriars, E.C., under the presidency of General A. Fraser, C.B., who, in moving the adoption of the report and accounts, said the change of the Company's administration and agency from Alexandria to Cairo had been somewhat of a strain on their resources; but no doubt the expenses would be recouped in the current and following years. The directors recommended the payment of a dividend of 6 per cent. on the preferred shares, leaving, after devoting £69 to depreciation of stores, £1,948 to be carried forward. The motion was seconded by Mr. H. Grëwing, and carried.

Altrincham Electric Supply, Limited.—This Company has been registered with a capital of £50,000 in £1 shares, to take a transfer from the Manchester Edison-Swan Company, Limited, of a provisional order granted to them by the Board of Trade, authorising the supply of energy for public and private purposes within the Local Board districts of Altrincham and Bowdon, and to carry on the business of electrical engineers. The first signatories are: W. J. Crossley, Altrincham, Cheshire; C. C. Dunkerley, Dunham Massey, Cheshire; W. P. J. Fawcus, Portinscale Hale, Cheshire; H. T. Gaddum, Bowdon, Cheshire; W. O'Hanlon, Bowdon, Cheshire; W. Warburton, Bowdon, Cheshire; and W. A. Arnold, 5, Cross-street, Manchester.

Dundee.—At a meeting of the Works Committee of Dundee Police Commission a letter was read from the Board of Trade with reference to a complaint by Mr. F. Freedman, High-street, concerning certain electricity meters lately in use in his premises. Mr. Freedman had applied for the appointment of an inspector to examine the meters, and to this the Board of Trade agreed, stating that Major Cardew, the electrical adviser to the Department, would be happy to make the test in the event of the meters being forwarded to the laboratory at London. The Works Committee of the Commission acquiesced in this arrangement. They, however, stipulated that if the meters should be found correct so far as the consumer was concerned, Mr. Freedman should pay all expenses.

Edison Gower-Bell Telephone Company of Europe, Limited. The report of the directors adopted at a meeting of this Company held last week was as follows: "The directors beg to submit to the shareholders their report and the accounts of the Company for the year ending December 31, 1893, showing a balance to the credit of revenue account on that date of £120. 6s. 10d., which it is proposed to carry forward. The Telephone Company of Austria was placed in liquidation on February 16, 1893, but your directors do not anticipate that any return of capital will be received on the 1,000 ordinary shares held by this Company. The action against infringers in Belgium is now being argued before the Court of Appeal at Liège, and the solicitors give reason to hope for an early decision."

Electric Traction Company, Limited.—This Company has been registered with a capital of £300,000, divided into 29,880 ordinary shares of £10 each, and 1,200 deferred shares of €1 each. The objects are to enter into contracts for the construction, repair and maintenance of, and to construct, equip, and maintain any works, including railways and other roads or ways to be used for traction by electricity, steam or other power; bridges, subways, roads, wharves, quays, canals and docks, water and gas works, including the laying of pipes for distribution; buildings of any kind, telegraphs and systems of telephonic communication, or electric lighting; and to work and carry on under contract, or as owners or lessees, any electric or other railway or tramway, telephonic, telegraphic, or electric lighting system, or other like undertaking. The first signatories with one share each are: Edwin T. Botwright, Frank P. Shuckard, W. H. Adams, H. D. Brooke, W. Bryson Butler, W. Y. Yeoman, and Geo. Dewdney.

Anglo-Portuguese Telephone Company, Limited. — The directors' report presented at the seventh ordinary general meeting of the Company, held at the offices, 53, New Broad-street, E.C., on the 29th ult., stated that the amount to the credit of profit and loss account, after making all deductions, and including the balance brought from last year, was £6,171. 16s. 9d., which amount it was proposed to carry forward to the current year's accounts, the declaration of a dividend being, on the advice of the Company's solicitors, postponed for the present. The expenditure on capital account for the year amounted to £3,003. 11s. 1d. The number of paying subscribers at December 31 last was—in Lisbon 1,110, of a gross annual value of £8,295; and in Oporto 1,161, of a gross annual value of £6,436, making £14,731, and showing a total increase in subscribers of 80, and in value of £721, over the preceding year. The continuance of the high rate of exchange between the two countries had again entailed a very serious loss, amounting last year to £2 061. 4s. 11d., which has tended to cripple the available financial resources of the Company.

Maidstone.—At a meeting of the Local Board last week, Mr. Barker called attention to the conditions enumerated by Alderman Ellis upon which the transfer of the electric lighting order was to be made to a company, and he suggested that those conditions should be entered on the minutes as embodying the reasons why the majority voted for the transfer. Alderman Ellis said it was true that he quoted nine suggestions as to the terms upon which he thought the transfer of the order should take place, but they were suggestions only, and did not form part of his amendment on that occasion. The Mayor remarked that these suggestions would all come before the Electric Lighting Committee in preparing the scheme for a transfer. Mr. Barker said he thought that they ought to be entered on the records, because those suggestions really had the effect of carrying the vote for a transfer. Mr. Tootell pointed out that some of the opponents of the transfer on the last occasion said the terms alluded to could not possibly be carried out. The subject then dropped, on the understanding that Alderman Ellis's suggestions would come up for consideration in committee.

City Lighting.—At the meeting of the Commission of Sewers on Tuesday, Mr. Turner said he had a matter of emergency to bring forward—namely, a serious failure in the electric light in the City last week. Mr. Ross (assistant engineer) stated that on the subject of the failure he had received a report from the electric lighting company to the effect that it was due to a damaged and defective cable, which, however, was speedily repaired. Mr. Turner said he thought it was most unfortunate that the electric light was liable to serious failures, especially as the gas was being removed from the streets. He hoped the engineer would impress upon the company the necessity for preventing, if possible, such failures in the future. Mr. Turner also complained that the company monopolised the pavements and various open spaces in the City with their materials to such an extent as to become an absolute scandal. Mr. Deputy Bedford said he would like to know the difference between the cost of gas and electricity. Mr. Johnson remarked that he believed that the cost of cleaning the present gas standards was something like £1,500 a year. Mr. Ross replied that the gas standards had now been removed from the main thoroughfares.

Electrical Engineering in New Zealand.—We quote the following from the New Zealand *Insurance, Mining, and Finance Journal*: "The partners in the New Zealand Engineering and Electrical Company, of Castle-street, Dunedin, are Messrs. R. H. Postlethwaite and Thomas Stevenson, who have supplied most of the lighting installations in the Middle Island. A considerable number of sluicing claims have availed themselves of a light which in every way asserts its superiority over the best lights produced by combustion. At Roxburgh, St. Bathans, Round Hill, and, in fact, everywhere where sluicing is carried on by night as well as day, the arc light has been successfully installed, with much satisfaction to both workers and proprietors. In most claims one of the hands does the supervision, in addition to his ordinary work.

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In the Otago installations the necessary power is usually obtained by means of a small Pelton wheel. At the Blue Spur, the electricity generated is used, in addition to its use for lighting the workings, for exploding the blasts required for breaking up the auriferous cement. The company are at present engaged in perfecting an invention for assisting the amalgamation of gold with mercury, by which it is believed that a long-desired means of saving the present immense loss of gold which is well known to occur in all gold mining will be obtained."

South Staffordshire Tramways Company.—A petition by shareholders for compulsorily winding up the South Staffordshire Tramways Company, Limited, came, on Wednesday, before Mr. Justice Vaughan Williams. The Company was incorporated by a special Act in 1889, its principal place of business being at Darlaston, Staffordshire. The capital of the Company was £86,580 preference capital and £129,650 ordinary stock. The petition alleged various fraudulent acts on the part of the directors, and misapplication of the Company's moneys; that improvident contracts had been entered into; that there were, in fact, only two directors, who did not constitute a quorum; that the meetings provided for by the statute had not been held, and that for the purposes of such meetings as had been held bogus shareholders had been created, and the *bonâ fide* shareholders had no opportunity of being heard; that the directors refused to call a meeting; and that the interests of the real shareholders were not safe in the hands of the present Board. The petitioners were holders of £50,000 worth of stock; the Company opposed, and were supported in opposition to the petition by holders of £48,000 worth. The Company was stated to be perfectly solvent, and objection was taken that the affidavits in support of the petition were not sufficient evidence to justify the grave charges made. The petition was directed to stand over till Wednesday next for the filing of further evidence.

Lighting of Cherryhinton.—A meeting was held last week at the offices of Lord John Russell and Co., St. Andrew's-street, Cambridge, to consider the advisability of forming a company for supplying the parish of Cherryhinton with electric light. Mr. C. Bland, who presided, said that if they had a company at once for the electric lighting of Cherryhinton, it would not have a gas company or any other company to oppose it. They knew Cherryhinton was a very important place, and was growing every day. It was estimated that an electric light station could be put down in working order for £4,000. It seemed to him to be a little company about to be established for the good of the parish. Lord Russell said they proposed at first to put down one boiler, one engine, and one dynamo. The whole of the plant and machinery, the building, the land, and the mains and transformers to the various houses, could be put down for between £2 500 and £3,000. Speaking of his own firm as contractors, he said they were willing to take about 50 per cent. of their contract in debentures. They would at present require a sum amounting to about £2,000 by subscription. Lord Russell, replying to questions by the Rev. Canon Beck, said they would be able to supply 500 lights with the sum he mentioned; that was as much as they could expect to have taken up in the first six months. The Chairman suggested that the meeting should be adjourned to see if they could get the funds, and to see if the proposed company would be a paying undertaking. After discussion, it was decided to adjourn the meeting, the Chairman, Mr. Clark, and Mr. Piper being chosen a committee to make enquiries.

The Blackpool Tenders.—The following is a list of the tenders received for lighting the United Methodist Free Church, Adelaide-street, by electricity:

Maunsell Mercier and Co., 5, Deansgate, Manchester (accepted)	£70	0	0
Briscoe and Shaw, 27, Preston-road, Blackburn	129	0	0
Scott and Mountain, Limited, Close Works, Newcastle-on-Tyne	118	0	0
J. McLellan, 37, North-gate, Blackburn	105	0	0
F. Stewart, Assembly Rooms-arcade, Blackpool	98	11	6
Corlett Electric Engineering Company, Robottom-square, Wigan	95	0	0
Fowler, Lancaster, and Co., Limited, Albert Works, Graham-street, Birmingham	87	10	0
W. J. Proctor, Duke-street, Nuneaton	87	9	6
Paterson and Cooper, Powsall-road, Dalston	87	0	0
E. Dewhurst, Talbot-chambers, Blackpool	79	15	0
Donnison and Parmiter, 10, Corporation-street, Manchester	77	10	0
T. H. Churton, 5, South-parade, Leeds	75	0	0
B. Verity and Sons, 29, Princess-street, Manchester	70	12	0
These tenders include electroliers.			
Edison, Swan, and Co., Temple-chambers, Brazennose-street, Manchester	57	10	0
Bowker Bros., St. Paul's-road, Preston	53	0	0
Crabtree and Harrison, Back Church-street, Blackpool	53	0	0
W. Banks and Co., 32, Corporation-street, Bolton	45	0	0
J. Berry, 93A, Fishergate, Preston	42	12	6
Furnis, Paterson, and Co., 85, Malcom-street, Heaton, Newcastle	38	0	0
Baxendale and Co., Miller-street, Manchester	55	0	0
These tenders do not include electroliers.			

Electric Lighting of Guildford.—At a meeting of the Town Council last week, the Town Clerk said that he had received a letter from the Board of Trade, which stated that with reference to the previous correspondence on the subject of the application by the Holloway Electricity Supply Company for an electric lighting order for Guildford, they (the Board of Trade), before coming to a decision in the matter, proposed to give the Corporation and the promoters an opportunity of placing their views before the Board of Trade. They had fixed the hour of 11.30 on March 31 for the meeting, and requested representatives of the Corporation to attend. The town clerk read a copy of the objections which were originally forwarded to the Board of Trade, dated January 12. It was therein stated that the Corporation gave their consent to the granting of the provisional order on condition that it gave them power to purchase within six months after the expiration of 10 years, and any six months after the expiration of any subsequent period of five years, under the second section of the Electric Light Act, 1888. They also stated in their objections that they had recently purchased the town mills, and that a report they had received from their engineer pointed out that the surplus water power there, after utilising what they required for pumping purposes in connection with their water supply, might be advantageously used in connection with the electric lighting of the town, and the Corporation had it under their consideration whether they would themselves take steps with regard to the provision of electric lighting for the town. Councillor Salsbury moved, "That the Mayor and town clerk may represent to the Board of Trade that the Council are prepared to take steps to carry out the lighting of the town by electricity at the end of five years." Alderman Carling seconded the motion. After further discussion the motion was put, and lost by seven votes to five. It was unanimously agreed that the Mayor and town clerk should represent the Council before the Board of Trade.

Cooking by Electricity.—A correspondent of the *Pall Mall Gazette* writes to that paper as follows: "An account of an interview at the Patent Office, published in the *Pall Mall Gazette* of Friday last, speaks of cooking by electricity merely as 'practicable.' It may interest readers of the article to know that in the United States it is an accomplished fact. At the Chicago Exposition a large space on the southern gallery of Electricity Building was occupied by a complete electric kitchen, where every day a culinary artist was busily engaged. The firm that made the exhibit at Chicago had as their motto the significant words, 'You push the button; we do the rest,' and in a prospectus they summed up the advantages of the system under 15 heads. The all-important questions of safety and cost remain to be dealt with. At Chicago I handled the wires in the electric kitchen again and again, and by taking pains to secure actual contact at two points, experienced the full shock of the current, which was nothing more serious than might have been caused by the slightest pressure of a pin point. The cooking apparatus can be brought into use wherever there is a circuit, arc or incandescent. The ordinary electric light fittings may be utilised; thus when the flatiron was shown in operation at the World's Fair, the globe of an incandescent lamp was simply screwed off, and the wire connected with the iron fixed in its place. Next, as to cost. I tried to get exact figures, and was assured by the representative of the firm exhibiting at Chicago that electric heat for the cooking, washing, and ironing of a family of six persons can be supplied in most American towns for 5dol., or £1 per month—that is, £12 per annum. If this estimate be correct, it is safe to predict that gas stoves and coal-ovens will, at least in America, be knocked out of existence for domestic cooking in 10 years' time. No coal, no wood, not even a match for kindling; no ashes, no smoke, no dust, no labour, no odour, no danger; no heat but what is actually utilised, and, consequently, no waste. These form a category of negative points of advantage that cannot be approached by any other form of cooking apparatus."

Claim for Electric Batteries.—In the Westminster County Court on Wednesday, the case of the Maquay Electric Light Company *v.* Wild was tried before his Honour Judge Lumley Smith, Q.C., and was an action by the plaintiff company to receive payment in respect of a quantity of batteries and electric light fittings alleged to have been supplied to the order of the defendant. Mr. Chilcott, solicitor, appeared for the plaintiff company, and said it would not be disputed that the goods were ordered and delivered, but he believed the defendant was going to say that he only gave the order on behalf of his brother, for whom he was acting as agent. The plaintiffs, however, would entirely deny that any such arrangement was even suggested. The Managing Director of the company was called, and said the order was received from the defendant in the ordinary way of business, and he asked that the goods should be delivered to his brother at Blackwall. Not the faintest suggestion was ever made to the effect that the goods were ordered on behalf of the brother, and he was never looked to for payment. A great many applications had been made to the defendant for payment, but he took no notice of them, neither did he ever take the trouble to dispute his liability until he was served with the summons in this action. He had been supplied with goods on previous occasions and had paid for them without any trouble. For the defence Mr. Wild was called, and admitted giving the orders for the goods, but contended that when he did so he made it perfectly clear to the plaintiff that he was acting as the agent of his brother, and that the latter would pay for them in due course. He had purchased goods from the plaintiff on many previous occasions, and had always paid for them, but in this instance he never undertook any liability in the matter. In giving judgment his Honour said that the man who gave an order for goods would in ordinary course be presumed to pay for them, unless he made it clear to the seller that he was acting as agent on behalf of another party. In this case he (the judge) was by no means satisfied that the defendant gave the plaintiff to understand that he was giving the order on behalf of another person. Judgment, therefore, would be for the plaintiffs for the amount claimed, with costs.

Result of Hanley Tenders.—The following is a list of the tenders received for the electric light wiring and fittings to the Corporation buildings—namely: (1) Town Hall, including Victoria

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Hall; (2) Free Library and Boys' Reading-room; (3) Museum and Technical Schools; (4) Baths; (5) Market Hall and Fish Market; (6) Butchers' Market; (7) Electricity Works—for the Corporation of Hanley. Mr. Joseph Lobley is the borough engineer and surveyor.

C. A. Hemingway, Richmond	£5,681
Crompton and Co., London	4,925
H. South, London	—
C. Smith and Sons, Birmingham	4,159
J. Blackburn, Nottingham	—
Laing, Wharton, and Down, London	4,152
A. H. Wood, London	4,121
E. M. Evans, Manchester	4,086
J. Defries and Sons, London	—
Bourne and Grant, London	3,986
T. Barton, Blackburn	—
Brush Electrical Engineering Company, London	3,980
Paterson and Cooper, London	3,915
W. A. Shaw and Co., Stockport	3,897
Graham and Biddle, London	3,873
Lea, Sons, and Co., Shrewsbury	—
R. Barnett and Co., Newcastle	3,865
Sharp and Kent, London	3,859
A. F. Joel and Co., London	3,789
Fowler, Lancaster, and Co., Birmingham	3,733
Marryatt, Lillywhite, and Co., London	3,726
J. E. Collum and Co., Leicester	3,657
Walsall Electrical Company	3,657
B. Verity and Sons, Manchester	—
Johnson and Phillips, London	3,651
New and Mayne, London	3,611
Manchester Edison-Swan Company, Manchester	3,585
Donnison, Parmiter, and Barber, Manchester	—
Maunsell Mercier and Co., Manchester	3,527
Baxendale and Co., Manchester	3,445
T. H. Heywood, Manchester	3,061
J. D. F. Andrews and Co. (to different specification)	3,047
Spagnoletti and Crookes, London (accepted)	3,034

Where no amounts are entered tenders were sent for some of the buildings only.

Electric Light in Edinburgh.—A meeting of the proprietors and tenants of property situated in George-street, St. Andrew-square, Charlotte-square, and the streets leading into these thoroughfares from Princes-street was held in Edinburgh on Tuesday in support of the movement to have these streets included in the scheme of electric lighting. Sir Thomas Clark was called to the chair, and in explaining the object of the meeting he said they were met to protest against the action of the committee of the Town Council in excluding these streets from the electric lighting scheme. George-street and St. Andrew-square were originally included in the scheme, and it seemed extraordinary that perhaps the most highly-rated parts of the city were to have no benefit from the electric light. Mr. Macmillan urged that the Town Council, in carrying out their scheme, should give effect to the recommendation of Prof. Kennedy and lay down conductors sufficient for all the purposes that might be required, so that the streets might not be opened up again. Councillor Mackenzie, convener of the Electric Lighting Committee, said he came there to afford any necessary information, and he was not to be looked upon in the meantime as taking any side in the matter. Prof. Kennedy's original scheme included George-street and St. Andrew-square, and he said it would require 1,300 lamps. That proposal was remitted to the Cleaning and Lighting Committee, and at one fell swoop they blotted out the whole scheme of Prof. Kennedy and scheduled certain streets—this new arrangement necessitating 30 lamps more than Prof. Kennedy had estimated. That scheme was adopted by the Town Council. Then other streets were added, including the Canongate and High-street, which brought up the number to 175 lamps. That was the position so far as the Town Council was concerned. Prof. Kennedy was going to light from a continuous-current cable, and if it were decided to light George-street, he would do it through that cable, so that all that would be required would be to join the wires from the arc lamps. To light George-street, Charlotte-square, and St. Andrew-square would require 60 lamps, and the cost would be £20 per lamp, which would represent £1,200, and from that they had to deduct £400 as the price that would be saved from the lighting of these streets with gas. A committee was appointed to arrange for a deputation to lay the matter before the Town Council at their next meeting. The Chairman said that if they should be defeated in their efforts on this occasion to influence the Town Council, he was not quite sure that they would not have to make a representation on the subject to the Board of Trade. At a meeting of the Edinburgh Town Council, held on the same day, the following motion was passed: "That it be remitted to the Lord Provost's Committee to erect any spare lamps left over of the 175 sanctioned by the Council, after the streets already arranged for are supplied, in Fountainbridge, west ward from Earl Grey-street."

Dublin.—At a meeting on Monday of the Corporation, Mr. J. L. Robinson moved the adoption of a report of the Electric Lighting Committee regarding the extension of the electric lighting plant. He said that tenders had been asked from Messrs. Fowler and Co, Leeds, and also from Messrs. Porte, Sykes, and Co. for the supply of some plant, and the contract was given to Messrs. Fowler and Co., Leeds, and that firm had promised to give as much of the work as possible to Dublin. Alderman Toole seconded the motion. Mr. Buckley said there was a second report in connection with the matter, and he moved the postponement of the present one until the second report came up. Alderman Pile moved that the report be referred back to the committee for further information and comparison, and that all contractors who have already tendered get the same information and specification as Messrs. Fowler and Co. Mr. Clancy seconded the amendment. Mr. Robinson did not think it would be right to send the report back to the committee. They had obtained the advice of skilled men in the matter, and they were anxious to have the plant running in September. He said the tender of Messrs. Fowler and Co. was the best one. The idea was to have as much of the work as possible done in Dublin, and they asked them to have the boilers made in Dublin. They said that would increase the estimate by £200. Mr. Clancy enquired whether they had asked Messrs. Porte, Sykes, and Co. the same question. There appeared to have been correspondence with one firm to the detriment of another. Mr. Robinson said the tender of Messrs. Porte, Sykes, and Co. was unsatisfactory. They took up the most satisfactory one and entered into negotiations with the firm. Mr. Lenehan was of opinion that the report ought to go back to the committee for a more satisfactory report. Mr. Clancy said he thought there was a good deal more wrong in the electric department than had come under the notice of the public, and he would move that the Electric Committee be amalgamated with the General Lighting Committee, so that they would have more members of the Corporation acquainted with the matter together. Alderman Meade thought the amendment would mean sending to every contractor who had already tendered and asking for new tenders. Alderman Toole said if they had any belief in their engineers and surveyors, they had no alternative but to take their advice. The Lord Mayor said if they adopted the amendment in its present shape they would impose an enormous difficulty in the way of carrying out the electric lighting, and he was sure that was not the intention of Alderman Pile. Tenders were received from various firms, and Messrs. Fowler's tender was accepted. It required improvement in certain points, and the committee asked them to improve it and to get Irish manufacture where possible, and Messrs. Fowler and Co. agreed to that. The committee had decided before opening up further communication with that firm to accept their tender. The amendment was then put, and lost by 20 votes to 18. Mr. John Reilly moved a further amendment to the effect that the report be sent back to the committee for further information simply. Mr. M'Auley seconded the amendment, which was carried.

Eight-Hours' Day in the Engineering Trade.—Mr. W. Mather, M.P., has made public the report of the year's trial by Messrs. Mather and Platt, Limited, at the Salford Ironworks, Manchester, of the 48-hours' week. It states that the full complement of men at the Salford Ironworks is 1,200, though the actual number employed at any given date necessarily varies according to the state of trade. The trades represented at the works are patternmakers, moulders (iron and brass), smiths, coppersmiths and tinplate workers, engine fitters, millwrights, electrical mechanics, turners and fitters, brass finishers, boilermakers, planers, drillers, borers, machine tool men, and labourers. The character of the work turned out during the year of trial was similar to that of the preceding six years—namely, general engineering work. The year's trial was made during a period of general trade depression. The piecework system received a thorough representation in the trial, as well as the fixed weekly wage system. No overtime whatever was worked, except for breakdowns and repairs. The period of the experiment was comprised in the 12 months commencing March 1 and terminating February 28, 1894. On making up the books it was found that, comparing the ratio of wages to turn-over in the trial year with the ratio of turn-over in the six preceding years, there was an increase of 0·4 per cent. in the former. Had prices ruled the same, the turn-over in the trial year would, however, have been greater, and the wages cost, instead of showing an increase of 0·4 per cent., would have shown a decided decrease. The firm had found a marked economy in gas and electric lighting, wear and tear of machinery, engines, gearing, etc., fuel and lubricants, and miscellaneous stores. In regard to the increased fixed charges the balance was in favour of the trial year. The credit from these items to be carried to the trial year was an amount equal to 0·4 per cent. on the net amount of the year's turn-over. Thus, by a coincidence, a saving of 0·4 per cent. was secured as a direct consequence of the shorter hours, which counterbalanced the debit of 0·4 per cent. in the increased wages cost. A curious fact was illustrated by the pieceworkers' statistics. The diminution in their total wages meant a proportionately less production in actual work turned out by them. But as the total output of the works during the trial year was greater than that of previous years, the diminution in the production of the pieceworkers must have been more than compensated for by extra production on the part of the day-workers. The report concludes with the following observations: "We have now an opportunity of showing the workpeople and employers in other industries how beneficial changes may be made by mutual arrangement instead of by rigid legal enactments. There is no doubt that the results obtained at the Salford Ironworks, together with those at other places, demonstrate that the two morning hours before breakfast are not worth the pains and trouble they cost, whether to workpeople or to employers. The effect on the workpeople must be most damaging both physically and mentally; otherwise we cannot account for the remarkable and indisputable fact that when these hours were struck off, as much work was performed, all the year round, as when these hours were employed. My observations and the careful supervision of our foremen have not detected that our workpeople have consciously made anything like a spurt in the trial year, hoping thereby to gain a permanent reduction of hours, with the intention of easing off afterwards, as some have thought would be the case.

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I attribute the full maintenance of our production through the trial year solely to the unimpaired and cheerful energy on the part of every man and boy throughout the day. . . . Our year's trial has convinced us that we have found the happy medium in the number of hours during which only one meal and one stoppage are needed, and this resolves itself into the eight-hours' day, or 48-hours' week."

The Electric Light Question at Bedford.—On the 30th ult., three deputations appeared before the Board of Trade, at the Whitehall-gardens, to urge their respective views as to who were the proper parties to supply the borough of Bedford with electricity. The Corporation were represented by counsel, Mr. Coward being instructed by Mr. T. S. Porter and Mr. Warwick Wade, solicitors. Mr. Sydney Morse, parliamentary agent for the Bedford Electric Lighting Company, was supported by Sir Henry Mance (chairman of the company), Mr. R. B. Stafford, Aldermen Haynes and L. Jessopp, Councillors J. Miller, C. Verey, C. D. Shelton, and Mr. W. B. Jessopp, who instructed Mr. Morse. Messrs. W. Roff, J. Harris, R. Hockliffe, R. P. Jarvis, H. Young, and W. E. Taylor were also members of the Ratepayers' Committee which had been formed to prevent, if possible, the provisional order held by the Corporation from lapsing into the hands of a company. After hearing the arguments adduced on each side, Sir Courtenay Boyle said: "This matter has been going on for a very long time. It is quite clear that there is not, at any rate, a consensus of opinion in Bedford as to what is best to be done. I think this is one of the cases where it would be better that the decision of the Board of Trade should be communicated at once. Therefore I am in a position to state to you what the advice will be that we shall give to Mr. Mundella, and if Mr. Mundella concurs, that will be the decision of the Board. I quite agree with Mr. Taylor that the primary interests that will have to be consulted are the interests of the ratepayers. The Board of Trade are glad to develop trade, and facilitate the efforts of such companies as Mr. Morse represents, but the principal parties to be considered by the Board of Trade are the ratepayers. Now we feel that in order to get at the views of the ratepayers of the borough of Bedford, the first persons we ought to consult are the Corporation, and we have the firmest possible reliance in the wisdom and discretion of the Corporation. But the Corporation have had an electric lighting order since August 4, 1890, and not done anything under that order at present, except to give to the difficulties of the situation their careful consideration. The time must come when consideration is not sufficient, and some definite action must be taken, and it seems as if the time has now arrived when, in the interests of a large section of the ratepayers of Bedford, some definite steps should be taken. If the Corporation will act upon their order, and will undertake to do something to show that they really intend to carry out their powers, the Board of Trade will be very loth to interfere with those powers. Therefore, this will be my first advice to Mr. Mundella. If the Corporation will, as soon as they can, pass the necessary resolution to supply electricity within the compulsory area proposed in the company's order, their assent will not be dispensed with and their order will stand, but if they will not so resolve, their consent will be dispensed with, and an order will be granted to a company. The ratepayers' interests will be safeguarded, because the Corporation's order will not be at once revoked. The compulsory area will be open to reconsideration, so that if the company get the advantages for which they contend they shall be liable to supply at once, or within the compulsory time, a rather more extended area than has been suggested. Something has been said about the position of the company. I have nothing whatever before me to lead me to infer that the company will not be able to satisfy the Board of Trade as to their ability. If the company do not satisfy the Board of Trade within six months as to their ability to carry out their powers in the compulsory area within the limited time, or if they do not conform to the terms as to the compulsory area, their order will be revoked. There is now an opportunity given to the Corporation to decide aye or no whether they will do something or agree together on doing nothing. If they do something their powers will stand, but if they do nothing they will forfeit their powers." The following is the text of order since forwarded by the Board of Trade: "If the Corporation will at once resolve to carry out supply in company's compulsory area before January 1, 1895, Corporation order will stand and their assent will not be dispensed with. If not, assent will be dispensed with, and order granted to company. But (1) Corporation order will not be revoked; (2) compulsion area will be open to consideration; (3) unless company satisfy Board of Trade within six months as to their ability to carry out their powers, their order will be revoked, or if they do not comply with the terms of the order. In such case the Corporation order will remain. If they do satisfy and do carry out, order of Corporation will be revoked."

PROVISIONAL PATENTS, 1894.

MARCH 27.

6212. **Improvements in and relating to conduits for electric railways.** Michel Angelo Cattori, 45, Southampton-buildings, Chancery-lane, London. (Complete specification.)

6218. **Improvements in or relating to electric keyboards for type-writing and type-setting machines and the like, also applicable for circuit-closing devices.** William Phillips Thompson, 6, Lord-street, Liverpool. (Charles Elmer Allen, United States.) (Complete specification.)

MARCH 28.

6241. **A method of depositing and affixing metals by electricity upon a medium which is fastened upon ceramic objects by burning in a kiln.** Frederick Alfred Rhead and Harry George Coleman, 6, Bath-street, Stoke-on-Trent.

MARCH 29.

6315. **An improved rotary electrical differential controlling device.** Alfred Lyster Shepard, 8, West Kensington-gardens, London.

6323. **Improvements in or relating to alternating-current apparatus or circuits.** William Morris Mordey, 46, Lincoln's-inn-fields, London.

6328. **Improvements in electric battery apparatus.** Jacob Ayton Archer, 55, Chancery-lane, London.

MARCH 30.

6366. **Improvements in electric arc lamps.** Ellis Vinson Cooke, Winton Ironworks, Patricroft, Lancs.

6368. **An improved apparatus for tightening telegraph wires and the like.** Edwin Alfred Hoad and Peter Simon, 5, Laurence Pountney-hill, London.

6396. **Improvements in and relating to ships' telegraphs.** Edward John Griffin and James Macnab, 96, Buchanan-street, Glasgow.

6402. **Improvements in electric accumulators.** George Edward Barker Pritchett, Theodore William Pritchett, and Archibald Gilbey Gold, 31, Soho-square, London.

6417. **Improvements in connection with switches for electric current transformers.** Albert Essinger and Thomas Harden, 55, Chancery-lane, London.

MARCH 31.

6458. **Improvements in dynamo-electric machines.** Sebastian Ziani de Ferranti, 27, Charterhouse-street, London.

6482. **Improvements in or relating to multiple telephonic systems and apparatus.** Prosper Moreau and Joseph Munier, 323, High Holborn, London. (Complete specification.)

6491. **Improvements in and apparatus for converting electric currents.** Sydney Pitt, 24, Southampton-buildings, Chancery-lane London. (André Blondel and Sautter, Harlé, et Cie., France.) (Complete specification.)

6495. **A process for protecting iron pipes from corrosion by passage of electrolysed chloride solutions employed as disinfectants.** Eugene Hermite, Edward James Paterson, and Charles Friend Cooper, 28, Southampton-buildings, Chancery-lane, London.

6497. **Improvements in apparatus for electrolysing chloride solutions employed for disinfecting.** Eugene Hermite, Edward James Paterson, and Charles Friend Cooper, 28, Southampton-buildings, Chancery-lane, London.

SPECIFICATIONS PUBLISHED.

1893.

4874. **Transforming, etc., electric currents.** Foster.
5198. **Electrolytic apparatus.** Hargreaves and Bird.
6684. **Gas, electric, etc., lamps.** Müller and Adkins.
7266. **Distributing electric energy.** Whitcher.
7713. **Gland joint for electric conductors.** Johnson.
8316. **Electrical propulsion of boats and vessels.** New and Mayne.
10584. **Electrolytic apparatus.** Castner.

1894.

2203. **Electric candle lamps.** Durlacher and others.
2514. **Electric bells.** West.
2562. **Electric tramways and railways.** Ashley.
2812. **Generating electric currents.** Tesla.
2900. **Electro-deposition of metals.** Rudholzner.
3223. **Heating gases by electricity.** Donaldson.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3⅛
— Pref.	—	2¼
Charing Cross and Strand	—	5
City of London	—	12¼
— Pref.	—	13½
Electric Construction	—	½
House-to-House	5	1½
India Rubber, Gutta Percha & Telegraph Co.	10	23½
Liverpool Electric Supply	5	6⅝
	4½	5½
London Electric Supply	5	1
Metropolitan Electric Supply	—	8⅜
National Telephone	5	4⅝
St. James', Pref.	—	8¼
Swan United	3½	3½
Westminster Electric	—	6

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NOTES.

Havre.—The Havre Municipality propose to introduce the electric light into the local hospitals.

Rodez.—A company is being formed to supply this little French town with the electric light.

Rouen.—An application is being made for a concession for four electric tramway lines in this town.

Avallon.—M. Judic has applied to the local authorities for powers to supply the electric light to this town.

Bombay.—The premises of the Royal Bombay Yacht Club have been lighted electrically by Mr. A. A. Crawford.

Society of Arts.—On Monday, at 8 p.m., the third Cantor lecture on "Photometry," by Captain W. De W. Abney, C.B., F.R.S., will be delivered.

Many Customers.—The City of London Electric Light Company have now the names of 1,602 customers on their books, representing 85,757 8-c.p. lamps.

Sherborne.—The boys at Greenhill, Sherborne, have been amusing themselves in the way of imaginary football with the beam of light projected from a search-light.

The Charing Cross-Hampstead Railway.—The Charing Cross, Euston, and Hampstead Railway Bill was read a second time in the House of Commons on Wednesday.

Wiesbaden.—The authorities have approved of a scheme for the construction of an electric tramway, and for the conversion of the steam line into an electric tramway.

Glasgow University.—The Cleland gold medal for the best essay on "The Relation between Measurements of Electrostatic and Electromagnetic Units," has been awarded to Mr. Adam B. Stewart.

The Blackpool Electric Tramway.—The work of remodelling this tramway and the electrical plant is now proceeding, and it is expected that the line will be again set in operation in about six weeks.

Islington.—The Finance Committee of the London County Council reported on Tuesday that the loan of £9,000 to the Islington Vestry for the purchase of site for electric lighting station has been completed.

Nuremborg.—The Street Tramway Company are now waiting the approval of the municipal authorities for the use of electric power on their lines. The contract is to be given to the General Electricity Company of Berlin.

International Railway Congress.—At the International Railway Congress to be held in June next year, under Section II., "Locomotives and Rolling-stock," the general question of electric traction will be considered.

The Tesla Polyphase Patents.—An action has been brought by the Westinghouse Electric and Manufacturing Company against the General Electric Company for alleged infringement of the Tesla polyphase patents.

New Brunswick.—A telegram from St. John, New Brunswick, states that the Consolidated Electric Railway Company has been sold by auction for 92,000dol. Mr E. C. Jones, the manager of the Montreal Bank, is the purchaser.

Students of the Institution.—A students' meeting of the Institution of Electrical Engineers will be held at 28, Victoria-street, S.W., on Friday next, the 20th inst. A paper on "Secondary Batteries," by Mr. G. C. Allingham, will be read.

Lighting in the City.—The City of London Electric Lighting Company, Limited, are now prepared to supply current in no less than 406 streets, courts, lanes, etc. Current will be available in most of the remaining streets in the City by the end of May.

Appointment.—Mr. W. E. Clarke has been appointed assistant electrical engineer at the *Daily News* electric light installation. He qualified himself for the appointment under Mr. Ronald A. Scott, M.I.E.E., Acton Hill Electrical Engineering Works, London, W.

Fire.—We regret to learn that a fire broke out on Wednesday evening at the works of the Fowler-Waring Cables Company, Henley-road, North Woolwich. A building of one floor, 100ft. by 15ft. in dimensions, was destroyed and much damage was done to a larger building of two floors.

Pumping by Electricity.—A daily paper a few days ago described the passenger lifts at the north tower of the Crystal Palace. The water for the tanks is pumped to the top of the tower by two 6-h.p. electric motors, the current being obtained from the mains of the Crystal Palace District Electric Supply Company.

Iron and Steel Institute.—The annual meeting of this institute will take place at 25, Great George-street, Westminster, on Wednesday and Thursday, May 2 and 3. Among the papers down for reading is one by Mr. D. Selby Bigge, "On the Application of Electricity as a Motive Power in the Iron and Steel Industries."

The Telegraph Service.—A Treasury return shows that the total receipts of the Post Office Telegraph Service in the year 1893 amounted to £2,526,312, the total expenditure having been £166,682 more than that amount. The total balance of expenditure over receipts since the transfer of the telegraph service to the State is £509,706.

Lectures.—A lecture on "Michael Faraday" was delivered by Mr. J. W. Leyshon last week at Cardiff. Mr. T. Scott Anderson, master of electrical engineering in connection with the Sheffield School Board, has arranged to give in the Central Higher School, Sheffield, three lectures on electrical engineering. The first was delivered a few evenings ago.

Personal.—Mr. Walter G. McMillan, F.C.S., F.I.C., has been elected lecturer on metallurgy at Mason College. He is the author of a treatise on "Electro-Metallurgy," in Messrs. Griffin's "Scientific Text-Book" series. Mr. A. J. Lawson, M.Inst.E.E., has been appointed engineer and manager of the County of London and Brush Provincial Electric Lighting Company.

The South Staffordshire Electric Tramway.—We understand that the working of this tramway continues satisfactory, both from a financial and public point of view. Mr. Alfred Dickinson, the general manager and engineer to the company, will probably read a paper shortly on electric traction before the Institution of Civil Engineers, with special reference to this line.

Effect of Heavy Gases in Lamps.—At the recent meeting of the American Institution of Electrical Engineers, Prof. W. A. Anthony read a paper on the "Effect of Heavy Gases in the Chamber of an Incandescent Lamp." The author maintained that the use of bromine vapour in the chamber prevents blackening and maintains the candle-power and efficiency more uniform.

Electrical Exhibition at Budapost.—In our last issue reference was made to this forthcoming exhibition. We now note that the Department of Science and Art has received through the Foreign Office a despatch from her Majesty's Consul-General at Budapest calling attention to this exhibition of electrical machine tools which is to be held there from May 27 to September 30 next.

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Lighting at Cardiff.—Considerable progress has been made in laying down the electric light plant. At the generating station the boilers are all in position, and the condensing plant has been put in. The engines are expected this week. With respect to the work in the town, very nearly all the pipe-laying has been accomplished, and nearly all the cables are in. The engineers expect that the whole of the work will be completed by July.

Units and Standards.—The American Institute of Electrical Engineers have approved the report of the Committee on Units and Standards recommending the provisional adoption of the term "gilbert" for the C.G.S. unit of magneto-motive force, the "weber" for the C.G.S. magnetic unit of flux, the "oersted" for the C.G.S. unit of reluctance, and the "gauss" for the unit of flux density.

Lighting in Sheffield.—The Sheffield Electric Light and Power Company, whose new station we described a few weeks ago, are inviting applications for a new issue of 6,000 shares of £7 each, making a total subscribed capital of £70,000, divided into 10,000 shares of £7 each. The increased share capital is required in order that the company may extend their mains into the residential districts of Ranmoor and Broomhill.

The £10,000 Prize.—It is stated that the Metropolitan Traction Company put into force the original time limit and withdrew its offer of a £10,000 prize on March 1. The reason assigned for not extending the time was that the State Railroad Commission had not accepted its offer to act as a referee. An American daily paper states that over 1,500 plans were submitted in competition. The Lawrence Electric Company, of New York City, has, however, entered a claim to the prize.

Queen Victoria-street Subway.—The London County Council have received an application from the City of London Electric Lighting Company for permission to place additional electric light mains, in bitumen casing and iron pipe, in the Queen Victoria-street subway, between St. Andrew's-hill and Water-lane. The Council have sanctioned the laying of these mains upon condition that the work is carried out under the supervision of the Council's chief engineer and at the cost of the company.

The Rabbidge Telephone.—A price list of the Rabbidge telephone has reached us from the India Rubber, Gutta Percha, and Telegraph Works Company, of Silvertown. This type of telephone has been designed for conversation over short lengths of line, as, for instance, in the case of communication between various offices, warehouses, etc., forming a group of buildings, or between the different rooms of a large warehouse or block of offices. The telephone can be easily manipulated, and the articulation is loud and distinct.

The Brighton Demand Indicator.—Considerable interest is being manifested in the Brighton demand indicator and its working, owing to its having materially improved the load factor at the Brighton station, and the units consumed annually per lamp installed. In this connection, Mr. Arthur Wright, the inventor, points out that the main idea involved in the Brighton system of charging was gathered from a letter of Prof. Kennedy, published at the end of 1892, in which he suggested the use of a recording ammeter, to be placed on the consumer's premises.

Stirling.—The Town Council, as mentioned in our last issue, had decided to oppose the application of the Caledonian Electric Supply Company for a provisional order to supply Stirling with electricity, and had also resolved to again apply for an order themselves. A petition to this effect was signed by the majority of the members and forwarded to the Board of Trade. The town clerk has now received a telegram from the Council's parliamentary agents in London to the effect that they have received a letter from the Board of Trade stating that they do not propose to proceed with the company's order.

Royal Meteorological Society. — An ordinary meeting of this society will be held at 25, Great George-street, Westminster, on the 18th inst. The president, Mr. Richard Inwards, F.R.A.S., will deliver an address on "Some Phenomena of the Upper Air." The meeting will be adjourned about 9 p.m. in order to afford those present an opportunity of inspecting the exhibition of instruments, drawings, and photographs relating to the representation and measurement of clouds, and of such new instruments as have been invented or first constructed since the last exhibition. This exhibition, which was opened on Tuesday, will close on Friday next.

The Lyons Exhibition.— There will be several electric tramways at the Lyons exhibition to be held this year. The first of these will be constructed by the Creusot Works, from the designs of M. Lombard-Gerien. It will be on the overhead conductor system, and it is proposed to use an alternating current of high potential in conjunction with transformers. On the second tramway, which will be constructed by the Compagnie de Fives-Lille, it is intended to employ polyphase currents. This line will only be worked experimentally, and no passengers will be carried. A tramway on the accumulator system will also be in operation, as well as one worked from overhead conductors by continuous current, the latter being designed by M. Claret. Electric lighting will be well represented at the exhibition.

The Driving of Wharf Cranes by Electricity.— Considerable interest is being manifested in the use of electricity for operating wharf cranes, and it is believed in timber trade circles that the firm who first bring out a thoroughly satisfactory electric jib crane for the use of timber merchants will have a wide field before them. It is submitted from the point of view of the latter that one of the features of advantage of electricity is that it admits of utilising the dynamo for cranework and lighting, no cranework being required after dark, and no lighting in the daytime. This fact, together with the advantage of being able to convey the power to any part of the timber yard without danger of fire, etc., offers a great inducement to timber merchants to generally adopt electricity for lighting and power purposes.

Woking Central Station.—The complete control of the Woking Electric Supply Company has been obtained by Messrs. New and Mayne, who are making alterations and improvements to the plant as will enable a considerable increase in the output of the station to be made. At present there are some 3,500 lights connected, and there is every prospect of greatly and rapidly adding to these. The chief alterations now being made are in the direction of reducing the coal consumption, running the machines synchronously, and automatically switching on and off the primaries of the single transformers for load and no load, as also in the cases where two or more transformers are running in parallel. This latter improvement is being made by means of the firm's automatic transformer switch, a notice of which appeared in our columns some time ago. There are already laid 10 miles of cable, which cover a large district, and many extensions are being carried out.

Rules for Electrical Construction and Operation.—We have received from Mr. W. J. Hammer, of 1,301 and 1,302, Havemeyer-building, New York, an advance copy of the standard rules recently adopted by the National Electric Light Association for electrical construction and operation. These rules are the outcome of the efforts of

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the association to induce insurance companies to recognise the necessity for a uniform code of instructions under which intelligent workmen and inspectors can act in harmony. The rules concern the erection and working of different electric light systems, and, in addition to the former rules and those adopted recently at the Washington Convention, the pamphlet is supplemented by the report of the special committee on the rating of arc lamps and a glossary of electrical terms. It is proposed to secure the general adoption of these rules in the United States. Mr. Hammer, it may be mentioned, is the chairman of the committee of the association on the subject.

A Large Transmission Scheme.—The Clear Lake Electric Company, has been formed at Sacramento, California, for the purpose of transmitting 40,000 h.p. from a point near Rumsey, Yolo County, to San Francisco, a distance of 75 miles. Water is to be taken from Cache Creek, the overflow of Clear Lake, at a point near Rumsey, whence it will be taken through three water-mains, each 6ft. in diameter, for a distance of 10 miles, where a fall of 500ft. will be attained. This will give, as mentioned, about 40,000 h.p. One interesting feature of the scheme is the method by which it is proposed to carry the power across the bay of San Francisco. The geography of the country is such that this must be done, otherwise the distance of transmission would be increased to probably 150 miles. It is intended that the line potential shall be 25,000 or 30,000 volts, and that step-down transformers shall be placed in a sub-station located at or near the water front of Oakland, whence the current will be taken at a materially lower potential across the bay into San Francisco, a distance of eight or ten miles.

Electrical Communication with Lighthouses.—The Royal Commission on Electrical Communication with Lighthouses and Light-vessels have presented their second report, which recommends the establishment without delay of electrical communication by aerial wires between the telegraphic system of the country and a number of shore lighthouses and lighthouse stations. The Commissioners state that it is with regret that they have decided to confine their recommendations in this report to shore lighthouses; but until more has been done towards perfecting the communication of those light-vessels and lighthouses which were mentioned in the previous report as having the strongest claim to immediate attention, the Commissioners hesitate to add to the list of light-vessels and rock lighthouses with which they consider that electrical communication should be made. The report also recommends that the general lighthouse authorities should be invited to consider the general question of signalling with a view to institute a universal system of visual and sound signals at all the various light stations on the coast of Great Britain and Ireland.

Deputation on the Pacific Cable Question.—An important deputation waited upon the Marquis of Ripon (Secretary of State for the Colonies) at the Colonial Office on Thursday of last week, the Earl of Rosebery (the Prime Minister) being present. The deputation was composed of Sir Charles Tupper (High Commissioner for Canada), Sir Charles Mills (Agent-General for the Cape), Sir Saul Samuel (Agent-General for New South Wales), Sir Andrew Clarke (Acting Agent General for Victoria), Sir James Garrick (Agent General for Queensland), Sir Robert Herbert (Agent-General for Tasmania), and Sir Westby Perceval (Agent-General for New Zealand), together with Sir Thomas M'Ilwraith and the Hon. Robert Reid, special commissioners in London for Queensland and Victoria respectively. The object of the deputation was to place three requests before the Government, one being that the Imperial Government should unite with Australia and Canada in the formation of an Imperial and colonial guarantee of the interest upon the £1,800,000 needed for the construction of a Pacific cable to be confined to British territory. Sympathy with the request was manifested by Lord Rosebery and Lord Ripon, and it was pointed out that the question would be considered at the conference to be held in June at Ottawa, at which the Imperial Government will be represented.

The African Transcontinental Telegraph.—It appears, from information furnished by the British South Africa Company's office at Cape Town, that the telegraph company which Mr. Rhodes formed last year in London shipped to South Africa 400 miles of telegraphic plant, with iron poles and wire insulators of the same pattern as used for the wire connecting Cape Town with Fort Salisbury. Of this plant 200 miles was sent to Beira, and thence, *vid* the Beira Railway and by ox-wagon, transported to Salisbury for the section of the line between that place and Tete on the Zambesi, traversing the auriferous Mazoe district. The other 200 miles of plant was sent to the Chinde mouth of the Zambesi and thence carried by steamers to Tschekwawa, a place about 140 miles up the Shiré River. Of this 200 miles, 80 miles is being constructed backwards in a westerly direction to connect Tschekwawa with the Zambesi at Tete. The remaining 120 miles is to be erected northwards to Blantyre and Zomba, the British Consulate in the Shiré highlands of Lake Nyassa. Some months ago constructors were sent to Tschekwawa, and they have already constructed some 50 miles of the 80 miles connecting the Shiré with the Zambesi. Of this, 20 miles, completed and in working order, is in the Portuguese territory. The southern section of 220 miles between Salisbury and Tete is being erected under the superintendence of Mr. Gordon, a nephew of the late General Gordon. This section crosses the Zambesi to join the Shiré section at Tete, where, the river being broad, it was proposed to erect a lofty iron pole on an island in midstream.

Can Gas Shareholders Vote on Electric Lighting?—The question as to whether gas company shareholders who are members of town councils have the right of voting on electric lighting matters at meetings of these authorities has been warmly discussed recently in different parts of the country. In this connection, the opinion of Mr. George Humphreys, Q.C., sought by Alderman Powell, of Monmouth, will prove of interest: "Proceedings at meetings of town councils are regulated by s. 22 and Schedule II. of the Municipal Corporations Act, 1882 (45 and 46 Vic. c. 50). By rule 13 of Schedule II. the council may make standing orders for the regulation of their proceedings and business, but from the fact that none was referred to I assume that there is no standing order of the Monmouth Town Council applicable to the case. That being so, the matter depends on sub-section 3 of section 22 of the Act, which provides that a member of the council shall not vote or take part in the discussion of any matter before the council or a committee in which he has directly or indirectly, by himself or his partner, any pecuniary interest. In my opinion, the mere fact that Mr. Alderman Powell and Mr. Howse are directors of the Monmouth Gas and Water Company did not cause them to have within the true meaning of section 22, sub-section 3, a pecuniary interest directly or indirectly in the matter in question. I think, therefore, that the Mayor was bound to treat them in all respects in the same way as an ordinary member of the Council, and that the mere fact that they are directors of the Monmouth Gas and Water Company does not disable them from taking part in the discussion of or from voting upon the scheme for electric lighting."

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The Regulation of Pressure in Electric Light Circuits.—A paper on "Some Methods of Regulating Pressure in Electric Light Circuits" was read on the 4th inst., by Mr. Wilfrid S. Boult, A.M.I.C.E., before the Liverpool Engineering Society. The author, after pointing out the necessity for very exact regulation of pressure in currents running incandescent lamps, owing to the greatly enhanced variation of light due to a small variation of pressure and the quick destruction of the incandescent filament if a large access of pressure takes place, referred to the Board of Trade limitations, and the question was then considered under the following heads: irregular speed of engine; varying terminal E.M.F. of dynamo with varying load; varying loss of E.M.F. in feeders to mains with varying load; and varying loss of E.M.F. in mains, service lines, and house wiring. Descriptions were given of the Willans-Crompton-Hartnell, the Porte-Manville, the Goolden-Lewis, the Richards, and the Jamieson governors as used with continuous current for regulating speed of engine or excitation of dynamo. Compound winding, feeder regulation, the three-wire system (with and without accumulators), in which the Manchester, Burnley, and Paris (Place Clichy) installations were instanced, with a reference to Dr. Hopkinson's station voltmeters without pressure wires, completed the consideration of continuous currents. Under the head of alternating currents, the Westinghouse, Ganz, Thomson-Houston, and Lowrie-Hall methods of regulation were described and commented upon. Numerous diagrams were exhibited illustrative of the various apparatus and methods described in the paper, which was stated to be written more for the purpose of affording to non-electrical engineers a general insight into the present state of the question than with the object of being interesting to the electrical expert.

Electric Illumination.—In his second lecture on electric illumination, delivered on Tuesday at the Royal Institution, Prof. J. A. Fleming began by briefly describing several forms of photometer, including Ritchie's and Bunsen's. He referred to the uncertain and unsatisfactory character of the unit of light supplied by the so-called "standard candle," and mentioned among suggested substitutes the amyl acetate and pentane flames of von Alteneck and Harcourt. He then passed to the consideration of glow or incandescent lamps. In all successful lamps of this type yet constructed the substance made incandescent has been carbon, it has been contained in a high vacuum, the lamp itself has consisted of a glass vessel, and the current has been led through the glass by platinum wires. The carbon filament is prepared from parchmentised paper or cellulose, and when finished is as elastic as steel. As it becomes longer when heated, provision must be made to prevent it from breaking. The horseshoe form of filament allows expansion freely, but a straight filament is mounted on a spiral spring. The vacuum in the bulb is produced by means of mercury air-pumps of various forms. Prof. Fleming also described the arrangement of lamps in series and parallel, and insisted on the necessity of a constant and uniform pressure if lamps were to have a long life. He then turned to the molecular physics of a lamp. Although a high vacuum, the space inside the bulb is by no means empty; besides a very considerable number of molecules in the air, it contains particles of carbon thrown off from the filament. These particles, which are the cause of the blackening of the glass often seen in lamps, are negatively electrified, as was shown by Edison. He placed a platinum plate in a lamp between the legs of the horseshoe filament and connected it through a galvanometer to the positive terminal. When a continuous current was passed through the lamp, the galvanometer was deflected, but if the connection was made to the negative terminal there was no deflection. The lecturer concluded with some remarks on the use of incandescent lamps.

Photometry at the Society of Arts.—The first of the series of Cantor lectures for the session of 1894 was delivered at the Society of Arts last week by Captain Abney, C.B., F.R.S., the subject being photometry. The lecturer said that the question was one which entered into our daily life and into the happiness of our homes, and he would treat it so as to give some idea of the general principles, restricting his remarks that evening to the scientific aspect. The term "photometry" had come to mean almost exclusively the science of the measurement of our household light. It was not possible, at present at least, to measure every kind of light. The measurement was made by the comparison of the illuminating values—by reflection from a screen, for instance. The most important thing to do was to fix a standard. Parliament had fixed one—viz., a candle, six to the pound. With this he disagreed entirely, as the standard could not be constant. The sperm candle was no longer what it was, and this was due to its improved quality. He showed the necessity of an unalterable standard, which should always give the same quality of light. There was one method which the lecturer said he had used with success in collaboration with General Festing for more than 10 years. This was the electric light, which was always the same. He mentioned incidentally that the methods used by him and his colleague appeared to have been rediscovered by a French *savant* within the last two years. The lecturer then proceeded to illustrate his remarks by projecting the image of the electric arc on the screen, showing that the light in the crater was very constant. Electric light was the whitest of all lights. Three different lights were compared—viz., the candle, gas, and oil—the difference of colour being shown. Light of any colour could be matched with an incandescent lamp, showing that all the lights which we use are due to incandescent carbon. This, of course, has always been suspected, and he proceeded to demonstrate it by analysing the flame of a candle. At the second lecture, delivered on Monday, the lecturer described the different methods of photometry. The lecturer said that, dismissing the standard candle test as imperfect, as he had explained in his first lecture, he would limit himself to the consideration of three only of the secondary standards—namely, the acetate of amyl lamp of Dr. von Hefner Alteneck, the pentane lamp, and the method known as the grease-spot. In the acetate of amyl system, which he greatly approved, he showed that the variation in the compounds of amyl employed made very little difference, and this had been ably investigated by Dr. Siemens. The pentane lamp, a 10-c.p. lamp, worked out by Mr. Dibdin and Mr. Sykes, was a very permanent standard and also simple and easy to work. The great point in photometry was to have a light of the same quality throughout. The method of comparison of two lights was then illustrated and explained. An interesting description and demonstration of the grease-spot method was then given, the nature and preparation of the discs (including Dibdin's improved disc) was explained, and the system of measurement with the standard light on one side and the light to be tested on the other was illustrated with the instruments themselves and by diagrams projected on the screen.

Electric Transmission of Power in Sweden.—Mr. Rob. Dahlander, of Vesterås, in an article in the *Elektrotechnische Zeitschrift* on the electric transmission of power installation at Hellsjön-Grängesberg, in Sweden, states that the late Mr. Jonas Wenström independently

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discovered the principle of the rotary current, and that the owners of his Swedish and Norwegian patents (the General Swedish Electricity Company, of Vesterås) have since 1890 been busily engaged in the construction and development of rotary-current machines. The first large installation carried out by the firm has been the newly-completed power-transmission plant in the Dalecarliens mining district, between Hellsjön and Grängesberg. Water power is obtained from a small stream at Hellsjön, a fall of 150ft. being available. The water is conveyed to the power-house by means of piping 1,700ft. in length, which is partly of wood and partly of wrought iron. There are four turbines of 100 nominal horse power, and one of 20 h.p. The large turbines run at 600 revolutions, and each is connected with an alternating dynamo by means of a clutch. The small turbine drives two direct-current dynamos of 3·3 kilowatts capacity of the ordinary Wenström type, which serve to excite the alternators. The generators have 14 poles, and at 600 revolutions give a frequency of 70 periods. This frequency was chosen as, in consequence of the long distance of the transmission (over eight miles), transformation was necessary. In other installations by the same firm where transformation is not required, a low frequency is generally adopted. The four generators are all alike. Two of them produce rotary current for the transmission of power. In the third machine, which serves for lighting purposes, one of the armature coils is cut out, and both the others are connected in series so that a simple alternating current is produced. The rotary-current generators work at a pressure of 150 volts per phase, and the lighting generator has consequently an E.M.F. of 260 volts, which is, however, raised to 270 volts by increasing the excitation. The fourth generator was intended as a reserve, but it is often employed for the transmission of power. The current is led to two switchboards, one of which serves for the power transmission and the other for the lighting and the exciting circuits. There are three transformers, two of which are for power and one for light. The pressure of the current for power purposes is here raised to 5,500 volts, and that of the current for lighting to 5,000 volts. Originally the neutral point of all the transformers was directly connected to earth. This, however, caused disturbances in the neighbouring single telephone conductors. Consequently, an earth-plate was brought into use, and the connections were so made that the pressure between the neutral point and the earth would not exceed certain limits. As a further precaution, the telephone wires were partly doubled. From the generating station five conductors are carried on oil insulators on posts. Where railways or roads are crossed, the current is conveyed by means of underground cables, but overhead wires are now being substituted for these, due safety being afforded by protecting nets. The current is utilised for lighting and for power at different portions of the Grängesberg mining field, the distances from the generating station varying from 5½ miles to eight miles. At present six motors are used, with an output of from 9 h.p. to 45 h.p., and are employed in working winding engines and pumps. The motors are of a synchronous type. Each motor has a special transformer. Friction couplings are employed to connect the motors with the machinery which they drive. Eight transformers are used in connection with the lighting, with an output of from 4·5 to 10 kilowatts, each of which supplies a group of lamps. At present there are 300 incandescent lamps and 25 arc lamps employed.

Coal-Getting by Electricity.—A paper on this subject was read last week by Mr. R. S. Williamson, of the Cannock and Rugeley Colliery, at a meeting of the South Staffordshire and East Worcestershire Institute of Mining Engineers at Birmingham. The author, after explaining the various parts of the Jeffery electric holing machine, gave particulars of the results of its working. He said that about the end of November his firm made arrangements to try one of these machines, and so far it had given satisfaction. They first commenced by using a machine to hole 4ft. under by 3ft. wide cut, and had since adopted a second machine to hole 6ft. 6in. under by 3ft. 6in. wide. It was put into the bass coal seam, as the holing in this seam was very hard. Difficulty was experienced in getting workmen to work the coal at what was considered a fair and reasonable getting price; but since the introduction of the machine this difficulty had disappeared. So far the machine had been worked by men at a daily wage, other workmen being engaged to do the blowing, loading up, and putting on the cogs. They employed three men with the machine—one man to superintend and work it, another to clear the dirt away, etc., the third to assist generally. In America, he was told, two men work the machine. The average distance from the generating station to the face of work was 750 yards. When they first commenced from the rib the roof was good, and an average of over 50 cuts in eight hours could be made. Since then the weight had broken the roof, and now 35 cuts was about a fair average. In an eight-hours' working shift the length of face cut, 4ft. under, was, on December 5, 40 yards, and on December 6, 65 yards; whilst the yield was 75 tons and 122 tons respectively. The total cost on December 5 was £1. 2s., and on December 6, £1. 8s. The cost per ton for machine was 3·50d. on December 5, and 2·16d. on December 6. The cost per ton for hand labour was 1s. The author was of opinion that the wear and tear on the machine would be very much less if the working parts were made stronger. The machine was better adapted for seams having good roofs and those of a non-fiery nature. One drawback was the length required from the working face to the back timber, or cog. In conclusion, he stated that the sparking from the brushes and commutator in their present form prevented the machine from being adopted in fiery mines. Some notes were read on Tuesday by Mr. Crankshaw, before the Manchester Geological Society, on Hurd's pneumatic electric coal-cutting machine. He stated that they had three methods of driving to choose from—steam, compressed air, and electricity. Steam, however, might be set aside at once as impracticable. There was much to be said in favour of compressed air. It was safe, and helped to cool and ventilate the workings, but the loss in transmission was very great. Electricity could be transmitted by the loss of not more than 5 per cent., and now that the difficulty from sparking had been overcome, it was, he considered, the motive power of the future. Hurd's machine was a combination of the two. It had the advantages of compressed air whilst the motive power was electricity, and, taking the mechanism and motive power together, it was decidedly the best machine he had yet seen. Briefly stated, it consisted of a cutter-bar drill and an electric motor connected by suitable gearing. Mr. Crankshaw then gave some technical details with regard to the construction of the machine and its method of working, remarking that it had a strong, neat, workmanlike appearance, and gave the impression of being able to stand the rough-and-tumble of the mine, from ironstone nodules in the coal to falls of roof on the face, without much damage. Mr. Hurd, the inventor of the machine, who was present, said, judging from the results already obtained in Yorkshire with the machine, that he had no hesitation in putting the saving, as compared with hand labour—even with the compressed-air machines of the old type—at from 1s. to 3s. per ton.

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PRACTICAL INSTRUMENTS FOR THE MEASUREMENT OF ELECTRICITY.

BY J. T. NIBLETT AND J. T. EWEN, B.SC.

XIX.

(Continued from page 348.)

RESISTANCE, *continued.*

Silvertown Testing Set.—This portable testing set, made by the Silvertown Company, consists of a couple of boxes—one containing a number of primary cells, and the other a galvanometer, collection of resistance coils, contact-maker, and other requisites for determining the conductor and insulation resistances of telegraph or telephone cables, electric light or power circuits, or other systems of insulated conductors.

The battery is divided into two parts—one for use in the measurement of conductor resistances, and the other for insulation. The former of these consists of four low-resistance Leclanché cells, giving an E.M.F. of about six volts, and is for use with the Wheatstone's bridge when testing the conductor resistance of a cable or other conductor for which an appreciable current is necessary. The other portion of the battery is arranged so as to give very small currents of high potential, and consists of 30 Leclanché cells of low resistance,

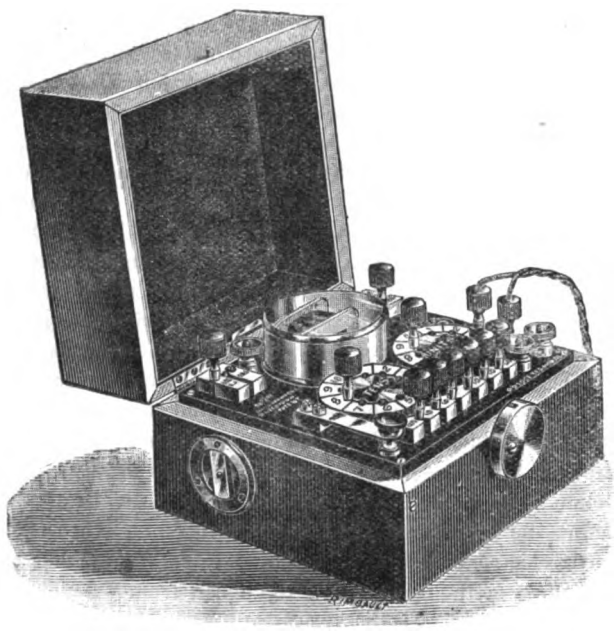

FIG. 46.—Silvertown Testing Set—General View.

capable of giving out an E.M.F. of 45 volts or more. These 30 cells are divided into three sets of 10 cells each, so that the whole, two-thirds, or one-third of the potential can be readily obtained. In the instructions issued by the Silvertown Company for the management of their testing sets, they expressly warn users not to use the high-potential battery with the bridge, or, in fact, to couple them up at all through a low resistance, as they would very quickly run down, and a considerable time would elapse before they regained their normal E.M.F.

The rest of the apparatus constituting the testing set is shown in Fig. 46, and is illustrated diagrammatically, with the under-board connections indicated, in Fig. 47. It includes a galvanometer with shunts and controlling magnet to alter the sensibility, a Wheatstone's bridge, set of resistance coils, terminals, and contact-maker. The connections between the two boxes are made by means of insulated flexible wires terminating in plugs, as shown in Fig. 46, and those between the apparatus and the conductor whose resistance or insulation is being measured, are made by flexible wires and binding screws in the usual way.

The galvanometer consists of a light magnetic needle swinging through an arc of about 90deg. in a coil of high resistance. The needle is so suspended that when the lid of the box is closed, it is lifted off its agate centre by means of the projecting lever shown in Fig. 47. This is of great importance in a portable instrument, as the fine suspension would be almost certain to get damaged were the needle point allowed to rest in the jewel when the apparatus is being carried about. The needle can be readily taken out and examined on withdrawing from the interior of the coil the slide on which it is pivoted, after removing the glass cover. The deflections of the needle are read off from a light aluminium pointer attached at right angles to the needle and projecting through the end of the coil to a calibrated scale, as shown in Figs. 46 to 49. The north end of the magnetic needle points towards the left side of the box when in its normal position, so that the aluminium pointer should point to the magnetic west when indicating zero on the scale.

The controlling magnet, as shown in Fig. 46, is pivoted on the side of the box in such a position that when the needle is hanging normally in the coil, its north pole points directly towards a vertical line drawn through the centre of the magnet. With the north pole of the controlling magnet uppermost, its effect upon the needle is opposed to that of the earth, so that the magnetic field in which the needle swings is weakened, and the galvanometer rendered more sensitive. With the south pole uppermost the earth's magnetic field is strengthened, the needle oscillates more rapidly, and the galvanometer is rendered about 40 per cent. less sensitive than before. The magnet is generally placed with the north pole uppermost so as to be as sensitive as possible when measuring high resistances such as insulation, and with the south pole uppermost when measuring conductor resistances. The galvanometer pointer can be brought accurately

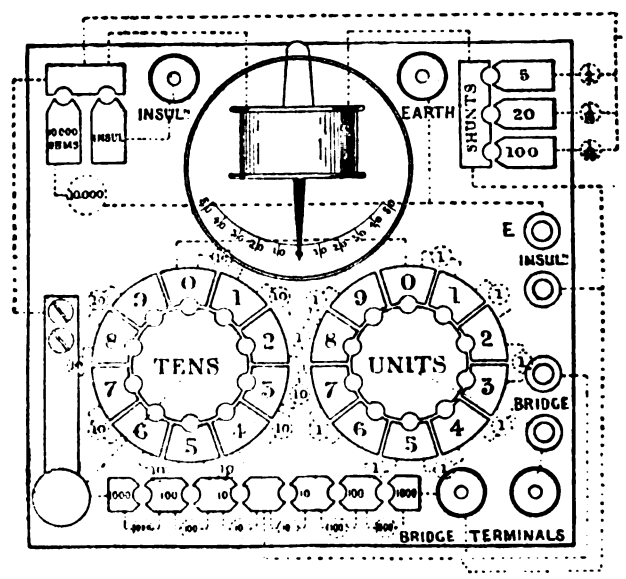

FIG. 47.—Silvertown Testing Set—Plan showing Connections.

to zero by slightly deflecting the controlling magnet to right or to left. In other examples of these testing sets the controlling magnet is a round bar about 2½ inches long and 3-16ths inch diameter placed above board at the left of the galvanometer, and so mounted that it can be moved out or in and turned round in a horizontal plane.

The galvanometer shunts, as shown in Figs. 47 and 49, are capable of reducing the current flowing through the galvanometer to $\frac{1}{1}$, $\frac{1}{10}$, or $\frac{1}{100}$ of the whole current generated by the battery; and in other examples only two shunts are provided, having values of $\frac{1}{10}$ and $\frac{1}{100}$.

The positions of the different resistance coils and all the under-board connections, are illustrated in Fig. 47. The coils and connections specially required when measuring conductor resistances are shown separately with the others omitted in Fig. 48, and similarly those for insulation resistance in Fig. 49. Before making a test the apparatus box should be placed on a level, or approximately level, surface with the galvanometer pointer towards the magnetic west and the controlling magnet vertical. The pointer can then be brought exactly to zero by slightly turning the magnet.

Measuring Conductor Resistance.—The parts of the apparatus used when measuring conductor resistance, as shown in Fig. 48, are the galvanometer, adjustable resistance, ratios, contact-maker, and four terminals. The shunt coils are omitted because they are not essential to this test, although

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before a balance is arrived at and the galvanometer deflections are inconveniently large, the galvanometer is sometimes shunted temporarily. The adjustable resistance consists of the two dials marked TENS and UNITS, the former containing nine 10-ohm coils, and the latter nine 1-ohm coils; and the ratios consist of pairs of 10-ohm, 100-ohm, and 1,000-ohm coils. The four low-resistance cells in the battery-box are attached by flexible leads with plug ends to the two plugholes marked BRIDGE, Fig. 48; and the ends of the conductor whose resistance is to be measured are connected to the two terminals marked BRIDGE TERMINALS. The plugs at the ends of the battery leads are shown in position in Fig. 46. The conductor resistance is then measured in the usual way by the Wheatstone's bridge method, as described under this head in a former article.

Suppose, for example, that the 100-ohm coil on the left side and the 10-ohm coil on the right side of the ratios are left unplugged, and that with 2 in the TENS coil and 6 in the UNITS the galvanometer gives a deflection of half a division to the right, while with 2 in the TENS and 7 in the UNITS the pointer indicates two divisions to the left.

R_1 therefore lies between 26 and 27, and is nearer to 26 in the ratio of **2** to $\frac{1}{2}$, so that it is = 26·2 ohms.

R_2 = 10 ohms and R_3 = 100 ohms.

$$\therefore R = R_1 \times \frac{R_3}{R_2};$$

$$= 26{\cdot}2 \times \frac{100}{10};$$

$$= 2{\cdot}62 \text{ ohms.}$$

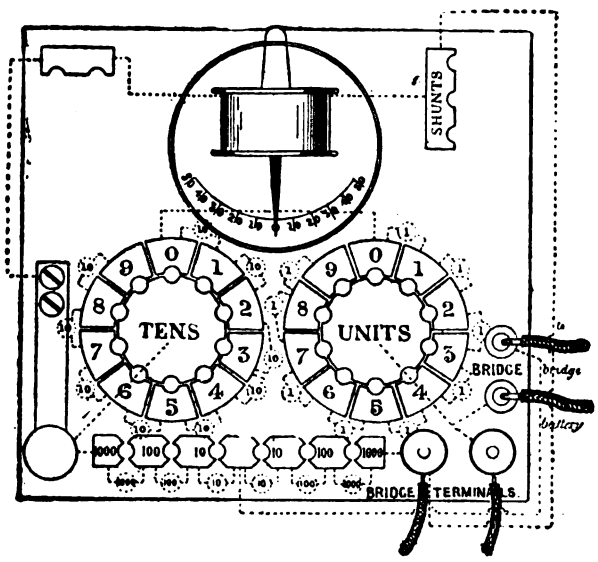

FIG. 48.—Silvertown Testing Set—Conductor Resistance Connections.

When measuring so small resistances as these it is highly essential to ensure good contacts at all the junctions, as the slightest extraneous resistance introduced into the circuit, whether from dirty or corroded terminals or imperfect clamping, is liable to entirely vitiate the results obtained. The Silvertown Company recommend the soldering to the ends of conductors, brass or copper plates slotted to pass under the loose head of the clamp terminal, so as to obtain an efficient contact. Again, although the internal resistance of the Leclanché cell used is low, they develop but a small E.M.F., and if allowed to remain long in circuit quickly polarise, so that they should be allowed to remain actually in circuit only so long as the galvanometer reading is being taken.

Measuring Insulation Resistance.—For this test all that is required is the galvanometer and shunts, the 10,000-ohm resistance coil, the block alongside it marked INSUL., and the four insulation terminals. The contact-maker at the left bottom corner is used to short-circuit the galvanometer. The conductor whose insulation is to be measured is connected to the terminal marked INSULN. at the top left corner, the other terminal, marked EARTH, being connected to earth or to the sheathing of the conductor. The terminals of the high-potential battery, consisting of 30 Leclanché cells, are attached by means of the flexible leads to the two plugholes marked INSULN. at the right of the apparatus box. As already described, this method consists in comparing the deflections of the galvanometer with a high resistance—10,000 ohms in this case—in circuit, and with the insulation of the conductor in circuit, the galvanometer being shunted in either or both cases, if required, to bring the deflection within measurable limits. The insulation resistance, R, is then found from these observations by the formula already given:

$$R = R_1 \times \frac{d_1 s_1}{d s},$$

where R_1 = 10,000 ohms, d the deflection, and $\frac{1}{s}$ the shunt used with R in circuit, and d_1 the deflection and $\frac{1}{s_1}$ the shunt used with R_1 in circuit. R_1 is put into circuit by plugging the block at the top left corner, marked 10,000 OHMS, and R is put into circuit by plugging the block marked INSUL. When neither of these is plugged the circuit is entirely open.

It is usually found in practice that it is necessary to employ the highest shunt power when the 10,000-ohm coil is in circuit if the whole of the 30-cell battery is used. With the insulation of the conductor in circuit, a lower shunt power is usually found ample, or no shunt at all when the insulation resistance is very high. As an example, suppose that with the 10,000-

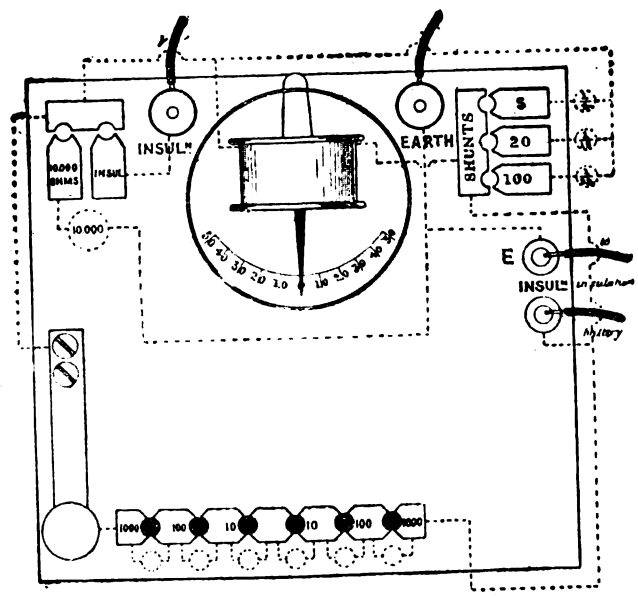

FIG. 49.—Silvertown Testing Set—Insulation Resistance Connections.

ohm coil in circuit and the galvanometer shunted to $\frac{1}{100}$, the deflection obtained is 27; and with the insulation in circuit, and the galvanometer shunted to $\frac{1}{20}$, a deflection of 15 is obtained. The insulation resistance, R, will be found as follows:

$$R = 10{,}000 \times \frac{27 \times 100}{15 \times 20};$$

$$= 90{,}000 \text{ ohms.}$$

Had the insulation been so perfect that a deflection of only 12 was obtained with the galvanometer unshunted, its resistance, R, would have been instead:

$$= 10{,}000 \times \frac{27 \times 100}{12 \times 1};$$

$$= 2{,}250{,}000 \text{ ohms};$$

or, $= 2\frac{1}{4}$ megohms.

(To be continued.)

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SOME NEW POINTS IN DYNAMO DESIGN.*

BY H. A. MAVOR, M.I.E.E.

I propose to bring before you some considerations which have been suggested by the development of a type of dynamo which my firm is now manufacturing. This machine was invented by Mr. W. B. Sayers. Before passing to these considerations it may be well, in order that the novel arrangement may be fully understood, to recall some important points which have to be considered in the design of continuous-current dynamo machines generally. For our present purpose we may practically confine our attention to the consideration of the two essential elements of the dynamo—viz., the magnetic and the electric circuits. (The useful part of the electric circuit being defined as that part which moves across at right angles to the magnetic field. The useful magnetic circuit consists of the iron field magnets, air-space, and iron armature core.) We need not for our present purpose concern ourselves in detail with the properties of the iron in the magnetic circuit further than to mention that experience seems to prove that pure cast steel is the best material for the field magnets, and soft annealed charcoal iron is the best for the armature core. The practice in this country is to build up the armature core of alternate sheets of charcoal iron and paper (the object of the interposition of the paper being to prevent the production of electric currents in the iron moving at right angles to the magnetic field). It is important that iron of the highest attainable magnetic permeability should be used, so that as little energy as possible may be expended in producing the magnetic field.

The E.M.F. of a dynamo depends upon the number of magnetic lines of force in the part of the magnetic circuit through which the useful portion of the electric circuit moves, and upon the rate of the motion. The two main objects in dynamo design are (1) to so direct the magnetising forces that the effect produced is confined as much as possible to the space through which the electric circuit is moved; (2) to so arrange the electric circuit that as much as possible of that circuit shall come under the description of useful electric circuit—that is to say, as much as possible of the part of the electric circuit included in the armature should move across the magnetic field at right angles. To attain the first of these ends, it is necessary to direct our attention to the form of the magnetic circuit, and as the electric circuit has to move across the magnetic circuit a space must be provided for its passage: this space is called the air-space.

For economy in cost of construction and uniformity of result, it is customary to use magnets in which the magnetic induction is obtained from electric currents generated by the machine. The form of the magnetic circuit has thus to be modified to admit the necessary winding of the electric conductor. Since the magnetic induction produced by the current in the winding depends upon the permeability and length of the magnetic circuit as a whole, it is evident that, seeing iron is more permeable than air, the air-space should occupy as little as possible of the length of the circuit; and that the iron portion of the circuit should be just long enough to accommodate the necessary winding. It is evident that while the iron and the air-space form the essential portions of the magnetic circuit, the circuit is not by any means confined to this region. That portion of the magnetic lines of force which returns from pole to pole outside the useful field of the circuit is treated as "leakage." The amount of this leakage with any given induction depends upon the form of the magnets and the length of the air-space. It would be possible to so design a dynamo that the greater part of the magnetising force would be lost in this way. The ratio of total field to useful field, in dynamos of the ordinary design, varies from 1·2 to as much as 2. The great importance of keeping the air-space as short as possible will be at once evident from this consideration. The determination of the length of air-space is, however, also governed by other considerations, which we shall discuss later.

Up to this point we have been looking at the dynamo as a simple magnetic circuit in which the induction is produced by an electric current passed round the iron core.

* Paper read on March 23 before the Physical Society of Glasgow University.

We now come to consider the effect upon the magnetic circuit of the currents in the electric circuit. The distribution of the electric currents in the armature and their effects upon the induction in the magnetic circuit depend upon the position of the brushes. For the purpose of considering the reaction of the armature currents upon the magnetic circuit, the armature conductors are divided into two groups: the active and the idle conductors—those in the air-space which are cutting through the magnetic field and those in the pole gap which, for the time being, are not concerned in the generating of E.M.F., but simply connect the two active groups to the brushes. Let us consider the effect first of those in the pole gap. The reaction on the magnetic circuit of the currents will be readily understood from the diagram.

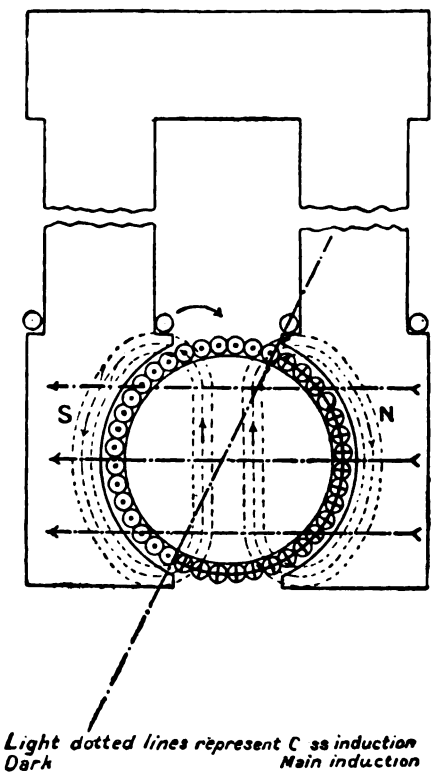

FIG. 1.—Conductors in Pole Gap.

In a dynamo the brushes would be placed somewhere near the forward pole tips. All the currents to the left of the brushes react against the induction through the armature, and the magnetising force has to be increased as the current increases in the armature to counteract this effect. This is done by what is called compound winding, the current being taken round the magnetic circuit in the opposite sense to the direction of the reacting armature current. The number of ampere-turns required to compensate for the back induction must be greater than the number of ampere-turns on the armature, because while the nearly whole magnetising force of the armature-turns is effective against the induction, the magnetising force of the compensating turns is subject to leakage to the same degree as that of the principal winding. If the machine be run upon open circuit, there is no armature reaction.

It will be seen from this diagram (Fig. 2) that the further back in the direction of rotation is the position of the brushes, the less is the back induction produced by the armature current. This leads to the consideration of the elements which determine the position of the brushes, or, as this is technically described, the diameter of commutation. Having ascertained what is the most advantageous position for the brushes, having regard only to the back induction effect of the armature currents, let us see whether the brushes can be placed in this position. We shall assume that the armature is rotating in a clockwise direction and that the S. pole is to the left or rearward position. The currents in the electric circuit which is in the air-space under the S. pole will be flowing towards the observer; the currents in the air-space under the N. pole will be flowing from the observer—the E.M.F. generated by cutting the lines of force in the magnetic field being in the direction stated. But, as

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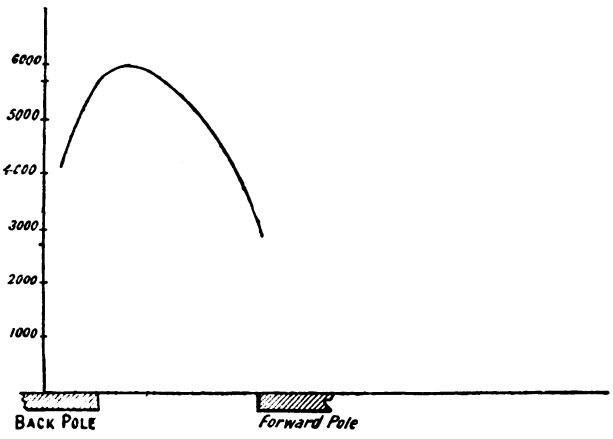
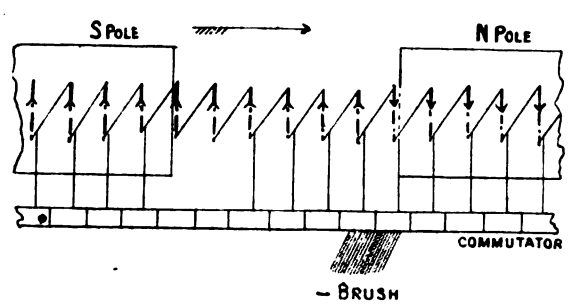
already stated, the magnetic field is not confined to the air-space; there is a flow of lines from the pole tips to the armature core extending forward into the pole gap, so that the conductors in the pole gap which are carrying the currents from active parts of the armature to the brush are some of them the seat of an E.M.F. opposing the flow of these currents. Further, as each armature coil passes under the brush, it will be seen that the current



Abscissæ = Brush Positions
Ordinates = Field Induction in C.G.S. lines per Centimetre

FIG. 2.—Diagram of Potential with Variation in Back Induction by Shifting Brushes with Full Armature Current.

in it has to be stopped and reversed in direction; but if it is still cutting lines of force so that the E.M.F. tends to keep the current flowing in the same direction, the current will be stopped and reversed only after the coil has passed from under the brush connection. Meanwhile it is short-circuited upon itself by the brush connecting its ends together and has a current set up in it, the magnitude of which depends only on the E.M.F. generated in it and on its own resistance. This current would not only waste energy by heating the coil, but by the breaking of the short-circuit would rapidly burn and destroy the brushes and commutator. It is therefore necessary to find some position of the brushes where this will not take place. Experience has shown that the necessary stoppage and reversal of the current must be accomplished by the aid of the magnetic field under the fringe of the forward pole (Fig. 3). Here it will be seen that when the coil passes



Thick dotted lines are the active Conductors of a Gramme Ring Seen through the Core

FIG. 3.—Diagram of Action of Commutation.

under the brush it is beginning to cut lines of force which set up an E.M.F. in it which tends to stop the current which has been flowing in it up to this point and to start a current in the opposite direction. In its passage across the upper pole gap, the coil has passed out of the influence of the S. pole, and the difference of potential across its ends when it begins to cut into the field of the N. pole is only that due to its resistance and the current for which it serves as a conductor; but this difference of potential across its ends and its self-induction will vary with the current which it is carrying, and therefore the best position for commutation will vary with the current which is flowing in the armature. It is for this reason that the brushes have to be moved forward as the load on the machine is increased. There is therefore in all ordinary types of continuous-current dynamos a necessary amount of back induction. It must be compensated for by an addition to the magnetising force of the magnetic circuit. This back induction, it may be repeated, is the effect of those coils in the armature which lie in the region outside the air-space. The coils which are not in this space cancel each other out as regards back induction.

Let us now pass to the consideration of the effect, upon the magnetic circuit, of that part of the electric circuit which lies within the air-space, and which is the seat of E.M.F. Returning to the diagram of direction of currents in armature we may consider first the magnetic circuit in which the cross magnetising currents lie, by itself, and then in its relation to, and reaction upon, the useful magnetic circuit of the dynamo. We find a band of conductors carrying current round the armature which act, as does the winding of any electromagnet, so as to produce a magnetisation which depends, as before, on the length and permeability of the various parts of the magnetic circuit of which the armature core forms a part, and upon the ampere-turns in the winding. (Here, again, the coils which lie outside of the air-space cancel each other out as regards cross-magnetisation.) In the diagram the direction of the flow of magnetic lines of force is represented as upwards through the armature core, and downwards across the pole-pieces of the field magnets. Taking this, now, in conjunction with flow of magnetic lines of force in the main magnetic circuit, we find that the magnetisation produced by the cross flow is such as to increase the induction in the two rear or trailing tips of the field-magnet poles, and to decrease it in the other two. Further, the cross-magnetisation of the armature and poles of the machine so effected, reduces their permeability, and this necessitates a further addition to the magnetising force in the main magnetic circuit (see S. P. Thompson, p. 93 and references).

The second of those effects is very important, as it not only affects the amount of winding required for the field magnets, but also affects the regulation or maintenance of a constant E.M.F. by the machine. The effect of cross-induction has been diminished by cross-lamination of the field magnets, although this is not often resorted to, and the regulation can be rectified by additional compound winding. The most important, however, is the effect upon the commutation of the armature currents. It will be seen that the corners of the poles which are weakened by the cross-induction are those under which it has been found best to perform the action of commutation, and it is necessary to provide that the cross-magnetisation does not so weaken this part of the field that commutation becomes impossible. This consideration fixes a limit to the possible shortening of the air-space, and to the possible current in the armature with sparkless collection at the brushes. We have, then, found certain limitations in the design of continuous-current dynamos which may be recapitulated. (1) The necessary existence of a varying amount of back induction. (2) A limitation to the reduction in length of the air-space by the necessity for keeping down the cross-induction so as to maintain the strength of the forward pole tip.

The first of these means that additional winding, and, therefore, additional length, is required in the field magnets over and above what is required to produce the induction through the armature were this back induction absent. The second means that still more additional winding is required to produce the induction across a longer air-space than is required for mechanical clearance and other requirements, of which we postpone consideration for the present.

We may now proceed to describe the modification devised by Mr. Sayers and its bearing upon these points. The device (Fig. 4) consists in the introduction, between the main winding of the armature and the commutator, of a part of a turn, a turn, or turns of wire called the "commutator coil." Two commutator coils are here shown under the brush: the armature coil which lies between them and is short-circuited by them and the brush, has just passed out of the fringe of the S. pole. The commutator coil B is in a strong part of the field; commutator coil A is passing into a weaker field. The resultant E.M.F. in the circuit which is shown with thickened lines, is thus downward in the commutator coil A, upward in the coil B, and downward in the section × of the armature between them. This E.M.F. is applied to stop the upward current in the armature section ×, so that when the position

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shown in the next diagram (Fig. 5) is reached, the armature coil is having a reverse current started in it before it passes over to the other side of the field. The resultant downward E.M.F. in the commutator coil A has died down to zero, and the difference of potential between the commutator plate under the brush and the point where coil A joins the armature is only that due to the resistance of the commutator

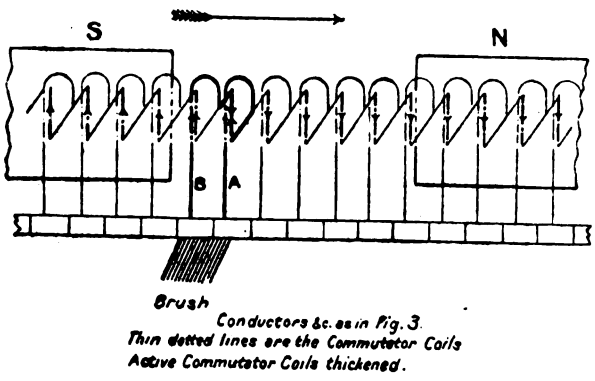

FIG. 4.—Diagram of Commutator Coils.

coil and the portion of the main current which it is carrying when its plate leaves the brush. This proportion will be small because there is an E.M.F. generated in B and C (which are still cutting lines of force), which E.M.F. assists the main current. The commutator coil must be so placed that the armature coil has passed completely out of the field before commutation commences.

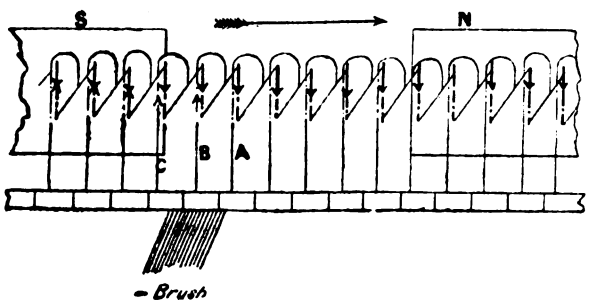

FIG. 5.

It will be seen that in an armature wound as shown in those diagrams, and with the commutator coils connected as shown, the effect of the commutator coils can only be obtained when the armature is running in the direction indicated by the arrow. Sparkless collection may be obtained when the machine is running in the other direction, but the brush must have a forward lead, and there is no advantage gained. The arrangement shown on the

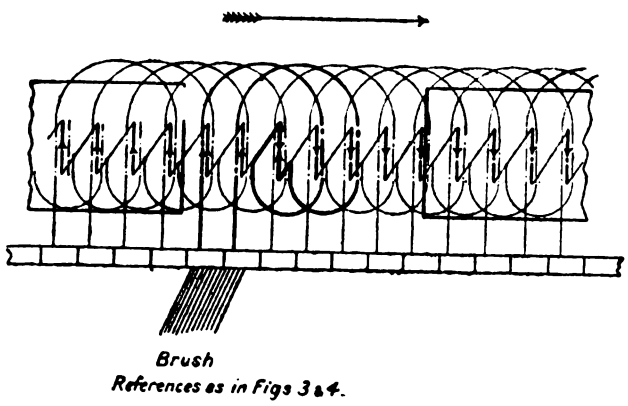

FIG. 6.

next diagram (Fig. 6) is therefore adopted. It will be seen that the connection of the coil is exactly the same, but that it has two sides—an active and an idle side; the side in operation being that which is under the pole tip when the coil is connected to the brush. Let us now examine the effect of this arrangement.

Referring again to the diagram of currents round the armature, in conjunction with the diagram of commutator coils, it will be seen that the brush is now in a backward position in relation to the direction of rotation, and that the wires between the pole gaps are not now all opposing the induction of the field magnets. In the diagram with the single commutator coils, it will be seen that of the conductors in the pole gaps. Those to the right of the brush are now assisting the induction, while those to the left of the brush are opposing the induction. The commutator coils carrying the armature current to the commutator are also opposing the induction. As the group of two or three commutator coils carries the whole armature current, this group accounts for two conductors in the main winding which carry only half the armature current. There is thus left a balance of magnetising turns. The resultant armature reaction is therefore now assisting the field induction, and machines can be and have been made on this principle without any winding on the field magnets, the armature itself supplying the whole of the necessary field. The saving in magnet winding of course results in a saving in the length of the iron magnets and a reduction in the size and weight of the machine. Further, the abolition of back induction renders unnecessary the compounding or compensating magnetising coils which are required to counteract its effects.

Coming now to the question of cross-induction, it will be seen that the cross-induction remains practically as before, but the effect of it is very different. Instead of weakening the portion of the field in which the currents are being reversed, it strengthens it, and thus the reversing effect increases with a rise of the current and consequent increase of self-induction in the armature sections—exactly what is required to produce a sparkless collection of the currents without shifting the brushes for changing loads. There still remains, however, the effect of the cross-induction upon the magnetisation. This effect is the crowding of lines in the tips of the trailing poles. The increase in the induction at this point results in a decreased permeability, and means must therefore be adopted to minimise this effect.

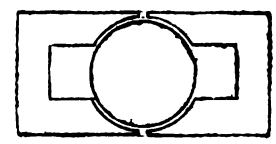

FIG. 7.

The form of magnet shown in Fig. 7 is adopted for this, among other reasons. (An account and comparison of various forms of magnets will be found in Kapp's "Dynamo Machines, Alternators, and Transformers.")

It has been shown that one of the advantages gained in this type of machine is a reduction in the length of the air-space. (The length of air-space in these machines varies from 1mm. in the smallest sizes to 4mm. in machines of 30 units), but the effect of cross induction still limits the shortening of the air-space by increasing the total flux in the poles, and thus reducing the permeability of the iron to the useful magnetising force. The calculation of this effect is, however, a simple one. The shortening of the air-space introduces other difficulties, which have to be met by a careful study of the conditions and adaptation of the design. The first of these is the heating of the pole-pieces by eddy currents set up by rapid changes in the induction caused by the alternate passage of the teeth and slots of the armature. This effect is also accompanied by a noise produced by the same means. The narrowing of the top portions of the slots or the complete closing of them, making what is known as a tunnelled core, gets over this difficulty, but increases the self-induction of the armature sections and renders necessary an increase in the reversing force.

This question of self-induction is frequently a stumbling block to students, but it need not be so. The E.M.F. which has to be set up in each armature section to stop the current which is flowing in it when it comes under the brush, is calculated precisely in the same way as the E.M.F. of the armature itself. The current in the coil is considered exactly as any magnetising current is considered, the reluctance of the iron and air of the circuit embraced by the coil and the induction in this magnetic circuit are calculated in the usual way, and the E.M.F. required to stop the current and restart it in the opposite direction, in the time during which the coil is passing

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from one side of the armature to the other, is the E.M.F. generated by the introduction into and removal from the coil of the lines of force in the field surrounding the armature current (see Fig. 8).

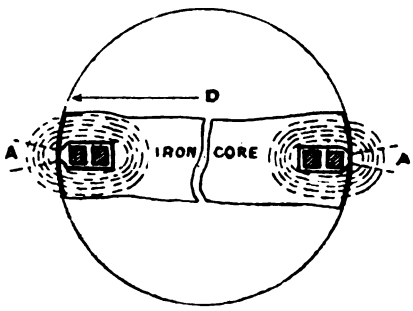

FIG. 8.—Part of Cross-section of Armature, showing magnetic field ("self-induction") round one armature coil of two turns, showing air-gaps, A A, in magnetic circuit.

The device described provides a means for producing the E.M.F. required for the reversal even where a tunnel winding is adopted, but it is better to leave an air-gap in the top of the tunnel than to increase the number of turns in the commutator coils. A tunnel so formed has the further advantage that magnetic leakage round the surface of the armature is reduced to a minimum.

A THREE-WIRE SYSTEM OF DISTRIBUTION WITH ONE DYNAMO.*

A French electrical company has recently made several interesting applications of a new system of distribution on the three-wire system by the use of only one dynamo. It is well known that the three-wire system and all methods generally of distributing current by multiple wires afford a notable saving in copper in the conductors as compared with the ordinary two-wire system. The three-wire system is usually carried out by connecting two dynamos in series, and thereby establishing a neutral point at the junction of the positive pole of one of the generators with the negative pole of the other. This neutral point serves as the place of connection with the compensating wire placed between the two outer conductors arranged one on the positive pole of one of the two generating sources connected in series, whilst the other conductor is connected with the negative pole of the system. The difference of potential between the two outer conductors, after making allowance for losses, is evidently the difference of potential at the terminals of the two generators arranged in series—that is to say, when the two generators are identical—twice that which would be produced by a single generator. The compensating wire, therefore, has in relation to the two outer wires a difference of potential equal to the half of that furnished by the entire system, so that by connecting each apparatus receiving current, on the one hand, to the compensating wire, and, on the other hand, to one of the outer conductors—care being taken to arrange matters so that as much as possible the current traversing the apparatus taking current on one side of the compensating wire is equal to the current traversing the apparatus arranged on the other side of this wire—each apparatus receiving current will only work at a pressure half less than that furnished by the source of electricity, and will, nevertheless, preserve its entire independence from the working point of view.

If the consumption of the apparatus in operation is equal on the two sides of the compensating wire, the current passes directly through the apparatus receiving energy from one outer wire into the other, and the middle wire has no current. On the other hand, if the number of apparatus is greater on one side of the compensating wire than on the other, and if the consumption is unequally distributed, the excess of current traversing the outer conductor which has the greatest charge returns to the generating source by the middle wire. This means that the quantity of current represented by the outer conductor having the lowest charge behaves exactly as in the first case—that is to say, it passes from one outer conductor into the other in traversing the receiving apparatus, and that the excess of current from the other conductor passes only into the compensating wire. The disadvantage of this system in principle is that two generators are required.

The system designed by the Compagnie de Fives-Lille allows of the feeding of a three-wire distributing network from a single dynamo, and without the production of sparking at the connection with the neutral wire. The arrangement of this system will be seen from Fig. 1, where the armature of a direct-current dynamo is revolving between two inducting poles, *n* and *s*. To simplify the comprehension of the illustration, the commutator is not shown, and the brushes, B_1 and B_2, have been placed directly on the winding, which in principle comes to the same thing. These two brushes are connected to the main cables, L_1 and L_2, which here form the two outer conductors of the three-wire system. We have seen that to establish a three-wire system a neutral point must be created in the generating system, and to which the compensating wire is connected. It is in the formation of this neutral point that the originality of the system under consideration lies.

Instead of joining two dynamos in series to obtain this result, we connect to two points diametrically opposed, *a* and *b*, of the armature of a dynamo, the two extremities of a coil, D, having great self-induction and a feeble ohmic resistance. During the rotation of the armature

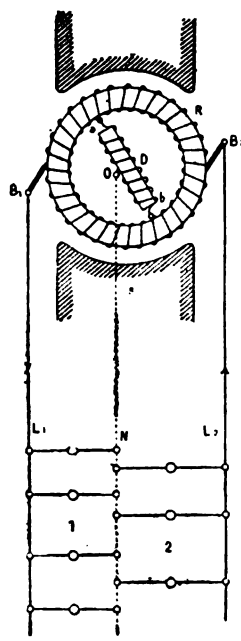

FIG. 1.

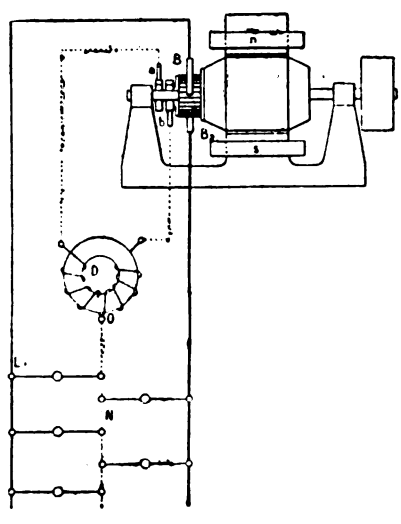

FIG. 2.

there will be produced between the points, *a* and *b*, an alternating E.M.F.; but as the coefficient of self-induction of the system has a great value, the alternating current created in the circuit will be weak. It is possible to reduce the intensity of this current as much as desired by increasing the coefficient of self-induction, L, of the coil, D, which can easily be done by arranging it on a core closed in iron. The point, O, in the centre of the coil has the mean of the potentials of the other parts of the winding, and not only is the difference of potential *a* O equal to *b* O, but at the same time the difference of potential between the points B_1 and O is equal to that existing between B_2 and O.

If we now place the compensating wire, N, by which the groups (1 and 2) of lamps are connected in series, into communication with the neutral point, O, and if the "bridges" 1 and 2 contain in operation the same number of lamps or apparatus, the neutral wire will remain without current. But if the "bridge" No. 1 is loaded more than No. 2, the excess of current of the first over the second will return to the dynamo by the compensating wire, and, reaching the point O, this current will be divided. As it is continuous, it will have no difficulty in traversing the coil, D, to penetrate the armature. It will be seen that by the aid of this device we are placed in exactly the same conditions as in the case of the use of two generators arranged in series. The

* Abstracted from *L'Electricien*.

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independence of the two consuming groups is complete, and if one or the other of these groups consumes more current than the other, the pressures remain the same, since the excess of current returns to the armature almost without any loss by the neutral wire, N, and by the coil, D.

As it is not always practicably possible to revolve the coil, D, with the armature of the dynamo, we can, without inconvenience, connect respectively two diametrically-opposed segments of the commutator, as shown in Fig. 2, to two rings arranged on the shaft, and upon which press two brushes, *a* and *b*, placed in communication with the two extremities of D, having great self-induction. This coil, which in this case is fixed, is arranged in a box at the side of the dynamo, and always has, as in the preceding case, its neutral point, O, connected to the compensating wire, N.

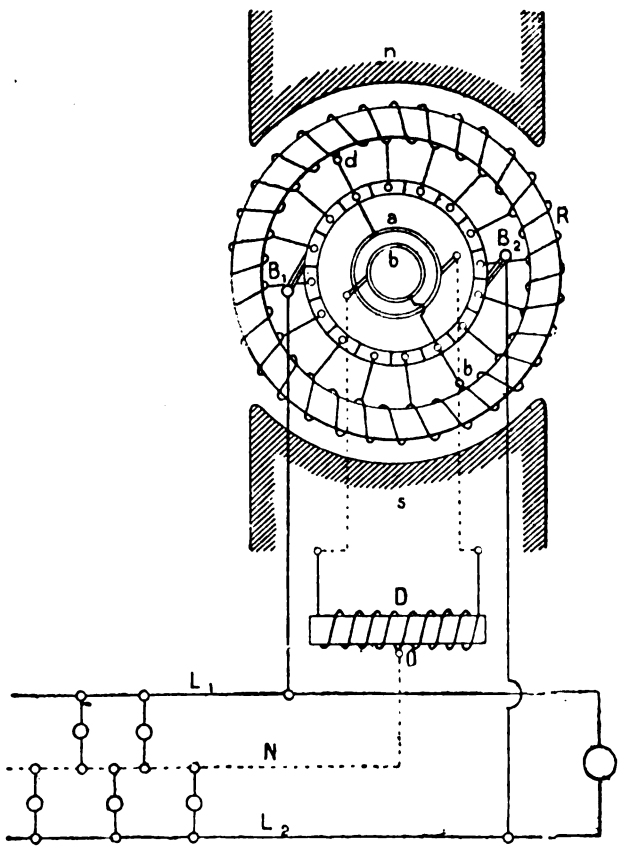

FIG. 3.

Is is very easy to employ this method for the purpose of regulating the pressure, especially in the case where the central station, as illustrated in Fig. 3, is distant, and supplies current at a pressure equal to the total tension of the two groups of lamps. In this case it is only necessary to insert near the places of utilisation one or several of these dynamos provided with self-induction bobbins. The brushes, B_1 and B_2, are put into communication with the main conductors, L_1 and L_2, in such a manner that the armature, R, commences to revolve and works as a motor; the neutral wire has not to be connected to the central station situated some distance away, and it then only serves for the compensation of the two circuits in use. This system can be applied both to dynamos and to motors, since the equalisers can work as well both as dynamos and as motors. This system can be applied to multipolar machines. This method allows of the distribution of current from 110-volt lamps in a radius of up to about 900 yards by the use of a single dynamo. This arrangement has been practically put into operation in six different instances with dynamos of 60 h.p., giving, it is said, great satisfaction.

Marseilles.—Experiments have been made in connection with a new conduit system for electric tramways, the invention of M. Chabeault. The French paper from which we abstract this item does not give any details of the system.

INSTITUTION OF ELECTRICAL ENGINEERS, Apr. 12.

Mr. R. E. B. CROMPTON in the chair.

At last night's meeting of the Institution the following candidates were balloted for:

Members.—Henry Robert John Burstall, 76, King's-road, London, N.; Alexander William Stewart, Crescent, Dalmuir, Dumbartonshire.

Associates.—Howard Tindall Adlard, 7, Northampton-park, N.; Malcolm H. Butcher, 24, Finsbury Park-road, London, N.; Charles Langstone, 8, Coleshill-street, Birmingham; J. H. Lee, Central Electric Lighting Station, Back of the Walls, Southampton; Andreas Peter Lundberg, 18, Regina-road, Tollington Park, N.; Gustaf Charles Lundberg, 18, Regina-road, Tollington Park, N.; David Mair, inspector of telegraphs, Bloemfontein Station, South Africa; George J. T. Parfitt, The Avenue, Keynsham, Bristol; Frederick William Sedgwick, Jesmond House, Epsom; Thomas Wright, 136, Bothwell-street, Glasgow, N.B.

Students.—T. D. Clothier, 13, Edwardes-square, Kensington; Dennis H. Felce, Kenmure Lodge, Elgin-avenue, W.; Herbert Grimwood, Faraday House, Charing Cross-road, W.C.; Frank Tracy Hamilton, City and Guilds Technical College, Finsbury, E.C.; Simon L. F. McLauchlan, 97, Hagley-road, Birmingham; Alec William Quennel, 44, Lower Kennington-lane, S.E.; Bernard J. Shillito, 25, Waldeck-road, Carrington, Nottingham; Frederick S. Spiers, 20, Christopher-street, Finsbury, E.C.; Frank Charles Thomas, City and Guilds Technical College, Finsbury, E.C.: James Toulmin, Linden House, Clarence-street, Loughborough; James Edward Salusbury Trelawny, 13, Lancaster-gate, W.

Prof. Ayrton read the addition printed in our last issue on "A Universal Shunt Box for Galvanometers," and also referred to certain objections which had been made, but he omitted to say where or by whom. Touching upon the question of the cost of the shunt boxes he instanced the following:

(1)	.....	10	.....	900	..... 9,000 ohms.
(2)	.....	100	.....	900	..... 9,000 ohms.
(3)	.....	1,000	.....	9,000	..... 90,000 ohms.

The estimate was the same for the third as for 1,000 ohms, and the second box was even cheaper. He stated that if the current was so small as to be hardly detectable it would be better to remove the shunt.

A brief discussion then took place on the paper on "The Best Resistance for the Receiving Instrument on a leaky Telegraph Line," written by Prof. Ayrton and Mr. C. S. Whitehead, and reported in our last issue.

Mr. W. P. Granville pointed out that in submarine cables the dielectric resistance increased greatly when the galvanometer was first applied.

Prof. Hughes said that the title of the paper was not quite accurate, for the "best resistance" would be none at all. The tests of electro-magnets should be made under the conditions in which they were used. He had made experiments, and found that the self-induction of the magnets induced an apparent resistance. The resistance of all electromagnets was too high, and his principle was to reduce resistance as far as possible. Makers had to design electromagnets for the average conditions of the line. All rapid instruments suffered from atmospheric conditions in hot climates such as Spain and Turkey.

The Author, in reply, regretted the fact that the telegraph people had not come forward to discuss the paper, as he had hoped to have drawn opinions from them. He had given a general mathematical solution in the paper. He pointed out that there was a certain resistance which was best, as there could not be convolutions without resistance. There was no difficulty in signalling when a line was in good order. What was required was to adopt the resistance to the line at its worst normal state.

The following paper was then read:

TRANSPARENT CONDUCTING SCREENS FOR ELECTRIC AND OTHER APPARATUS.

BY W. E. AYRTON, F.R.S., PAST-PRESIDENT, AND T. MATHER, ASSOCIATE.

It is well known that electrostatic instruments require to be screened from outside electric disturbance in order that their indications may be correct; but it is not so generally recognised that instruments intended to measure small forces, such as certain types of electromagnetic voltmeters, delicate vacuum gauges, etc., are liable to give wrong readings from an electric attraction being exerted on the pointer, such as is produced by the glass cover when it is touched or cleaned.

There is on the table here a well-known type of gravity electromagnetic voltmeter, which may be found on the switchboards of many English and continental electric light stations. At the present moment its terminals are not connected with the electric light mains of the building, so that it should indicate zero pressure. Let me, however, but stroke the right-hand side of the glass cover with my finger, and the pointer, as you see, at once turns to 80 volts or more. Conversely, let the terminals of the voltmeter be connected with the electric light mains: the pointer should point to about 100 volts, for that, as you know, is the pressure supplied by the Westminster Company. The voltmeter appears to be indicating correctly, but, on stroking the left-hand side of the glass cover, the pressure, as read by the instrument, appears to suddenly fall to some 40 volts; and a similar effect is

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produced if a piece of wash-leather or dry waste be used in place of the finger.

If, then, it is possible to cause this instrument to indicate at will 60 or 80 volts too high or too low, how impossible must it be or feel sure that the glass cover—which is, of course, maintained in a dry condition in a hot engine-room—has not been electrified by some accidental touch of the coat sleeve sufficiently to cause an error of 3 or 4 per cent. in the reading of this voltmeter!

We find that it is not merely with this particular type of voltmeter that an error can be produced by stroking or rubbing the glass cover, for other electromagnetic instruments that we have tried can also have their pointers deflected in the same way, but not to the same extent.

Nor, of course, is this source of error in any way connected with a voltmeter being an instrument constructed to measure an electrical magnitude, for it would equally exist if the glass were clean and dry and the controlling force remained of the same magnitude, no matter what was the quantity the instrument was constructed to measure. For example, on the table there is a vacuum gauge, the wheel-sector-pinion of which has been replaced with an Ayrton-Perry magnifying spring. This gauge is, no doubt, very sensitive, for you observe that the pointer moves even when I produce an extremely slight diminution of pressure by rotating the short length of indiarubber tube as slowly as I can; the change of pressure on pinching the tube, or even on dropping it, is indicated by the pointer. On the other hand, the pointer is of glass, and therefore is not suitable for being acted on by an electrostatic force; still, a stroke on the glass cover, as you see, causes the pointer to deflect through several degrees.

It has been known for a long time that it is possible to screen an instrument from such outside electrostatic disturbances by surrounding it with a metallic cage composed of wire or of strips of tinfoil. Such a method of screening, however, has the great disadvantage that it renders it difficult to observe the exact position of the pointer from a distance, for the wires or strips of tinfoil cover up the pointer more or less. We therefore thought of placing the pointer underneath the metallic dial of our electrostatic voltmeters, and of only allowing the tip to project through a slot in the dial plate. But this method we abandoned on trying it 18 months ago, for to make the screening good the visible part of the pointer must be reduced to a spot, and the exact position of this spot we found less easy to read at a distance of several feet than that of a long black line, which is the appearance of a pointer when it is visible along its whole length. This method of screening has, however, we understand, been recently adopted by a firm of instrument-makers.

We next considered whether it was not possible to make a perfectly transparent conducting screen, so that, while the electrostatic screening of the pointer should be practically perfect, the pointer and dial should be as easily seen as if the screen were not present. Our first idea was to make the glass cover double, and to insert between the two sheets of glass a layer of clear conducting liquid. Fearing, however, trouble from leakage of the liquid, or from the liquid becoming gradually turbid, and giving the dial a dirty appearance, we turned our attention to depositing films of solid matter on the inside of the glass cover or shade of sufficient thinness to be practically transparent, but with the solid particles near enough together to be conducting. We tried smoke, silver deposited in layers of various thicknesses, mercury vaporised and deposited, sal-ammoniac vaporised and deposited, etc., but we were quite unable to obtain in this way both transparency and electric conduction.

After a conversation with Prof. Boys, when discussing the problem that we were then engaged in solving, we commenced experimenting on varnishes with the view of arriving at a varnish which should be as hard and as transparent as clear shellac, but which, instead of being an insulator like shellac, should be a sufficiently good conductor to allow of the instantaneous production of an induced electric charge to balance the electrostatic action of any outside body. Glass plates were coated with gum, with coaguline, with the gelatinous electrolyte used in accumulators (composed of sodium silicate and dilute sulphuric acid), with isinglass dissolved in acetic acid, with gelatine dissolved in acetic acid, with isinglass dissolved in a mixture of acetic and sulphuric acids, and with gelatine dissolved in the same mixture. After much experimenting, we arrived at the following two methods of coating a glass cover or shade, which gives perfectly satisfactory results:

No. 1.—Dissolve ½oz. of transparent gelatine in 1oz. of glacial acetic acid by heating them together in a water bath at 100deg. C. To this solution add half the volume of dilute sulphuric acid, which has been prepared by mixing one part of strong acid with eight of distilled water by volume, and apply the mixture while still warm to the glass shade, which should be previously polished and be warm. When this film has become very nearly hard, apply over it a coating of Griffith's anti-sulphuric enamel.

Method No. 2.—Thin the gelatine solution, prepared in the manner previously described, by the addition of acetic acid (say, two volumes of acid to one of the solution), and after polishing the glass, float this thinned solution over the glass cold. Drive off the excess of acetic acid by warming, allow the glass to cool, and repeat the floating process, say, twice. Thin the anti-sulphuric enamel by the addition of ether, and float it over the gelatine layer applied as just described. Expel the ether by heating, and apply a second layer of this thinned anti-sulphuric enamel.

With experience, such as Messrs. Elliott and Messrs. Paul have at length acquired after much practice, a layer can be applied, either according to method No. 1 or No. 2, so that, when finished, it is quite hard to the touch, and so transparent that it is only by looking at the glass plate obliquely that the presence of the varnish can be detected. It is also so conducting that when a P.D. of several thousand volts, alternating with a frequency of 200, is set up between the needle and inductors of one of our electrostatic voltmeters, the pointer, which is metallically part of the needle, is not visibly attracted by a metallic rod held just outside the glass close to the pointer, this metallic rod being electrically connected with the stationary inductors.

Without experience, however, it is somewhat difficult to apply the coating so that it is not either cloudy or a comparatively poor electrostatic screen, or both.

This second electromagnetic voltmeter—which, like the former, has been kindly lent us by Mr. Barley, of the Knightsbridge electric light central station—looks exactly like the other one, and, indeed, behaved exactly like the other one when we received it. It has, however, had a layer of our transparent varnish applied on the inner side of the glass subsequently, and you will find that you may rub the glass as much as you like, or even hold a rubbed stick of ebonite near it, without producing any effect on the pointer.

Again, these two clear glass shades, belonging to gold-leaf electroscopes, are one of them coated with our varnish, and the other not. Which is the uncoated one is at once apparent from the alteration produced in the deflection of the gold leaves when I approach a stick of rubbed ebonite near the lower part of the glass shade of the uncoated one, for no such change in the deflection is produced, as you see, when the ebonite rod is brought near the glass shade, which is protected by a layer of this varnish applied on the inside.

On the conclusion of the reading of this paper, it was decided to proceed with the perusal of the paper on "An Astatic Station Voltmeter," also by Prof. Ayrton and Mr. T. Mather, and to discuss both papers together. We shall give this paper in our next issue.

Mr. Mordey, who opened the discussion on the two papers, congratulated the authors on the features of the instruments that had been described. To show on a large open scale, at any particular part of the scale, was the most important feature brought out in direct-current reading instruments for a long time. Instrument makers had, as a rule, directed their energies to getting proportionalities in scales, but it was of more importance to have a very large and open scale. He hoped the authors would pursue their labours further and give them an alternating voltmeter with the same features. The instrument described was only suitable for direct currents which were not quite obsolete, but they would like to have the same features in alternating-current instruments. The authors were also to be congratulated upon the screen. He thought, perhaps, that he was the first to draw the attention of the professor to the necessity for something of the kind.

Mr. Crompton stated that the electrification of the glass was well known to every apprentice in central stations, as was also the way in which it was prevented. No inconvenience had, to his knowledge, arisen from the occurrence. It was rather an interesting thing to get up that phenomenon by warming up by means of the lamps. That would also not have happened if they had not had such a spring as the present. The defect was shown very strong in electrostatic instruments. They were greatly indebted to Prof. Ayrton. With regard to the other paper, he thoroughly agreed with the statement as to the requirements of a good station voltmeter. He opined that instruments already existed that many of them had carried out before, and some of the authors' improvements were not new. He had not seen the hand of the pointer, but he had drawings of it before him. That method had been used by his firm for some time past, as had also the clamping arrangement. The way in which he got out of the difficulty by using a moving coil had one serious defect—namely, it was costly. The Weston instrument was expensive, and it was a luxury to have one in a station. Commercially it would be found that the instrument described would be a costly one, and would not be within the reach of many of them. It was for that reason that they had been trying to make astatic instruments in a more simple way. At present the price of an instrument might be taken at £4, and he doubted whether the instrument referred to could be produced at that figure. They usually had one *good* voltmeter in a central station, and used it as a reference voltmeter. They had also a number of other voltmeters on the switchboard sufficiently close to the reference voltmeter for the purpose, and the errors from the reference voltmeter were known and noted. The error might sometimes be one per cent., or one and a-half per cent., and those at the switchboard were accustomed to make allowances for them. They found no difficulty in providing themselves with voltmeters, which were astatic within that limit of error. He thought that Prof. Ayrton would not be able to make very sensitive instruments with three coils, since the weight of the coils, etc., would necessarily render the instrument sluggish. With regard to open scales, he believed they had been made by different firms—Hartmann and Braun, for instance—and it was not a difficult thing to make an open scale as Mr. Mordey had suggested for alternating currents.

Prof. Ayrton, in reply to the discussion, said that Mr. Mordey was not correct in stating that he was the first to direct his (the speaker's) attention to this electrostatic action. With regard to Mr. Crompton's remark that it was only necessary to touch the voltmeter with the finger to rectify the deflection, it was a curious fact that a central station engineer had just informed him that such an action caused a greater deflection. The clamping devices had been used for three or four years in connection with their electrostatic voltmeters. Mr. Crompton was wrong about permanent magnets producing a sluggish instrument.

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THE
ELECTRICAL ENGINEER.

Published every Friday.
Price Threepence; Post Free, Threepence Halfpenny.
Editorial and Publishing Offices:
139-140, SALISBURY COURT, FLEET STREET,
LONDON, E.C.

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TO CORRESPONDENTS.

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THE TRAMWAYS INSTITUTE.

The occasion of the meeting of the Tramways Institute at Manchester may be taken to express regret at the very little progress electrical traction for tramway work is making in this country. The reason is not far to seek, but if any progress is to be made at all this reason must be well understood. In the first place, although the various managers have been shown by figures, statistics, and argument that electrical traction ought to pay, nothing has been said that convinces them as to its commercial practicability. They ask for proofs obtained from English lines, and these have yet to be given. The success of such traction on the South London Railway and at Liverpool is no proof that it will be successful on ordinary tramway lines. With South London it was Hobson's choice; with Liverpool, the case was not much different. All tramway managers are now awaiting Mr. Dickenson's paper on the working of the South Staffordshire lines—a paper which, we believe, will be presented to the Institution of Civil Engineers. Even if Mr. Dickenson succeeds in convincing the most sceptical as to the value of electricity, that will not induce managers to be very eager in taking up this kind of traction. Assuming, then, that figures are forthcoming which will definitely prove the practicability and cheapness of electric traction from the managerial point of view, there is still something to be desired. A tramway line in operation is fully equipped. Altering from horse to electric traction means the expenditure of additional capital, and the question at once arises, Will the increased expenditure bring increased returns upon the total capital expenditure? If it does not, what is the advantage of the change? If it does, the advantage is at once seen, and conviction of tramway interests on this point will soon put the required capital in the hands of managers. If a line does not now pay, the question will be somewhat different, and assume the shape of, Can it be made to pay by the alteration? The inability to pay dividends is generally from lack of passengers, and it is difficult to see how one form of traction will increase the number of passengers to any large extent. While, then, we regret the want of progress in electric traction in this country, we cannot be blind to the reasons which have made tramway managers cautious. From the humanitarian point of view, horseflesh in traction work should be abolished; but nowhere in the world's history have commercial undertakings been carried out from this point of view. No one who understands horses can for one moment ignore the fact that traction work is perhaps the most killing that horseflesh is subjected to, and would gladly see inanimate materials used in its place. Those, like us, who have advocated and do advocate the use of electric traction, advocate such use because from figures put before us, from our knowledge of the possibilities of electricity, we firmly believe that its use would in most cases where it is proposed lead to increased returns, the increase being proportional to or even greater than indicated by the

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increased capital outlay. Only would this be the case, however, when the installation was properly designed and economically managed. We have always considered that the lighting station should also be the power station, as in many cases this would be an immense advantage to both parties. The over-lapping time would have to be arranged for in the station working, but we believe the economy would be greatly in favour of power and light from one roof rather than from separate establishments. Little straws tell the way the wind is blowing. And the mere fact that tramway people are getting more and more desirous of information about electric traction shows that they are beginning to feel an increased interest in the matter. Although not in this country, it is a significant fact, and will not be without weight here, that Brussels, which long since tried and rejected certain forms of electric traction, has again returned to that love, and probably before the end of the month will have the electric cars in full work. The tramways there are through broad boulevards, and the trial this time is to be by means of an overhead system. The wires are not unsightly—in fact, we doubt if ordinary passers-by would notice them so much as they do telegraph or telephone wires. If, then, a city given up to pleasure has no æsthetic uproar against overhead wires, we do not see why the examples of Leeds and South Staffordshire should not be followed in similar situations. Leeds is mentioned not because it offers a good example of electric traction prosperity, but because the system is overhead, and is used just at that one part of Leeds which possesses the greatest natural attractions. The district around Roundhay Park is naturally pretty, yet we have heard no resident complain, but rather they have expressed thankfulness that the overhead system existed. To sum up our points: managers must first be satisfied on the money question; those who control old lines must be further satisfied that a new expenditure will bring in commensurate returns; and lastly, that overhead systems are not objected to in places wherein they have been tried.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

THE HERMITE PROCESS AT WORTHING.

SIR,—With reference to Dr. Kelly's report on the above, which you noticed in your last issue, permit us to point out that in our opinion the samples submitted to Drs. Klein and Dupré were not fair samples of the treated sewage, and that our view was supported by several members of the Worthing Town Council at their meeting last Tuesday. As a consequence of this feeling, the Council decided to consider the report as confidential, and not to adopt it or print it till it was confirmed by the investigations now being undertaken by the British Institute of Preventive Medicine. Unfortunately, Dr. Kelly had on his own responsibility allowed a large number of copies of the report to be distributed throughout the country. As you have given publicity to the report, we rely on your sense of fairness to give equal publicity to our protest.—

Yours, etc.,
PATERSON AND COOPER.

London, April 9, 1894.

OBITUARY.

The death has just taken place at Saratoff of M. Paul Jablochkoff, who was born at Serdobsk (government of Saratow) in 1847. The deceased, who belonged to a distinguished family, was appointed director-general of the Moscow-Koursk telegraph lines in 1871. While occupying this position he became deeply interested in the subject of electric lighting. In the following year M. Jablochkoff lighted by means of an arc light the track on the Moscow-Koursk section in front of the locomotive hauling the Imperial train on the occasion of the serious outbreak on the part of the Nihilists. The failures met with induced him to make improvements in the apparatus used. Since 1875, when he withdrew from the Imperial Telegraph Service, he devoted his time to the development of science. In 1876, M. Jablochkoff proceeded to Paris, and was subsequently sent to London to represent M. Bréguet at an exhibition of scientific apparatus. Returning to Paris, he made a long series of experiments, which resulted in the production of the Jablochkoff candle, and which gave a great spurt to electric lighting. In 1878 the Avenue de l'Opera, at Paris, was lighted by Jablochkoff candles, and the system soon extended to Rome and to London, the Thames-embankment being so illuminated. In reference to this, Major Flood Page writes as follows to the *Times*: "There is no doubt that he did a great deal in directing the attention of the very small body of electricians in 1876-77 to the practicability of electric lighting, and much credit is due to him for his original work and the advance he made. For some time his electric candle held its own, and was undoubtedly the best system then in existence; it is still in use in Indian mills and many other places. In spite of the fact that he was supported in St. Petersburg by an illustrious personage, this clever Russian officer was not a successful man, as we men count success. Nevertheless, that St. Petersburg, which was behind the other capitals in the use of gas, and Moscow, which was not lighted by gas till 1866, have their central electric stations, and palaces, houses, and streets electrically lighted, is in no small measure due to the interest taken in M. Jablochkoff, and the impetus given to electrical advance in Russia by his original work. Like many inventors, he was very sanguine, and was, I am afraid, a very disappointed man; his works at St. Petersburg were large and well planned, but when, some years ago, I saw them he was working hopefully and bravely, but under financial and other difficulties. It can hardly be denied that M. Jablochkoff was one of the ablest and most original of the band of practical electrical pioneers." M. Jablochkoff took out patents for various inventions, and his death is much regretted.

ELECTRIC TRACTION ON LONDON RAILWAYS.

BY FRANK B. LEA.

Everyone at all interested in the development of electric traction must feel considerably pleased at the success which has attended the first year's working upon the Liverpool Overhead Railway, the details of which may be gathered from the extremely interesting and valuable papers lately read before the Institution of Civil Engineers by Messrs. Greathead, Fox, and Parker, the responsible engineers for this line. This feeling of pleased satisfaction may well be intensified on remarking the way in which the investing public has shown practical monetary support during the past few weeks towards such electric railway projects in London—viz., the lines between Waterloo and the City, and Charing Cross and Hampstead—as have crystallised sufficiently for the purpose. These lines, it will, moreover, be remembered, are based on the principles adopted for the City and South London Railway—not at present a very great financial success, but doubtless offering full justification for its existence as a pioneer line. If it were possible to plan and execute a line or lines in London after the model of the Liverpool Overhead system, the smaller capital expenditure as compared with that required for underground lines would

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naturally prove a great incentive to their immediate development. It is with the idea of examining into this question, or rather the possibilities of utilising for electric traction the railways at present worked by steam power, that this article is written.

The entire electrical equipment of the Liverpool line is stated to have cost about £80,000, and proves capable of operating a three-minute service on a double line about six miles long. Such an amount is considerably less in proportion than the expenditure upon rolling-stock alone for a line similar to the Metropolitan or Metropolitan District: and the question may therefore very well come up for treatment as to whether we might not secure important developments in electric traction at comparatively small outlay by utilising the surface and other lines already built, whilst at the same time pushing forward with all good will the new underground projects which will serve to complete the network around and through London.

Electric railway traction appears—in its present stages, at any rate—to be particularly and pre-eminently suitable for what may be called a "glorified tramway" service; that is, the greatest working economy and efficiency may be obtained on lines where there is a constant stream of light traffic at short intervals, where the trains run—as on the City and South London and the Liverpool Overhead—to and fro between two terminal stations, like a weavers' shuttle, or else continuously round a circle. Now, it is tolerably certain that the average Londoner, although he may think himself well acquainted with the ways and means of transit in London, would feel considerably astonished at the number and importance of existing railway services in the Metropolis which partake of this character, and which might, so far as that is concerned, appear to present a suitable field for the use of electric working.

There is, however, at least one fundamental difference or distinction between the electric railways already established and the steam railways thus suggested, which has a most important bearing upon the possibility of electric traction ever coming into use on the latter. The electric lines are isolated absolutely; they each run between fixed points and make no connections whatever for traffic purposes with adjacent railways. There is, of course, no serious objection to their doing so. It is simply a fact that at present traffic is confined solely to the lines in question, without interchange to other lines. When, however, we come to examine the steam railways where "shuttle" or circular traffic is to be found, the numerous junctions and connections with other lines involve so much interweaving of trains that the possibility of electric working becomes somewhat questionable, for reasons which may be detailed later on.

There are, roughly speaking, five great railway systems in the Metropolis upon which the shuttle or circular form of traffic may to a greater or less extent be found. Of these, naturally the most important section comprises the underground lines—Metropolitan and Metropolitan District—so far as the inner and outer circles are concerned, with, perhaps, one or two of the short extensions. Plenty has, perhaps, already been written upon the question of working these lines by electricity, and a great deal has been publicly said with regard to it, though apparently not enough to effect any real good in so desirable a direction. The financial difficulties involved appear to be too great for those now in authority to overcome, the condition of the lines being anything but favourable for obtaining and spending more money even upon improvements.

Assuming, however, that these difficulties, under other conditions, would not prove in any way insuperable, it can only be said that there is a crying necessity for the use of electric working on these lines. The present foul atmosphere alone would be sufficient reason for the change, whilst so far as the circle and shuttle trains are concerned, to work these by electricity would, if we may judge from results at Liverpool, effect considerable economy in time, labour, and, therefore, money. Is it, however, possible or practicable to work this traffic in such a manner whilst at the same time allowing steam-driven trains from other lines to exercise running powers, as they now do, upon the lines proposed to be operated electrically? Taking, for instance, the Inner Circle alone, besides the Circle trains, there must be accommodated traffic from the London and North-Western Railway, which runs a service from Broad-street to the Mansion House, *vid* Willesden; the Great Western Railway service between Aldgate and the Mansion House, *vid* Addison-road; the District service between New Cross, Richmond, and Wimbledon; the Metropolitan trains between Aldgate, Hammersmith, and Richmond; besides traffic from the lines running out to Acton, Ealing, and Hounslow; and the Outer Circle trains.

So far as the permanent-way is concerned there should be absolutely no obstacle whatever of any serious nature to the running of ordinary steam-driven trains upon electric lines; and the question of persuading *all* the companies involved to change or modify their rolling-stock need not, therefore, be raised at the outset. Much good might be effected by withdrawing the steam locomotives on the Circle trains alone, at the outset, leaving the remainder of the entire system to be changed or converted as opportunity may offer. Apparently, however, the irreconcilability of the two main interests involved—viz., the Metropolitan and District Railway Companies—is so great that nothing but strong pressure from the shareholders upon the respective directorates will ever effect the much-desired change. This, however, is by the way. An obstacle to the introduction of electric working of more importance even than the alterations required in the permanent way, etc., is the impossibility in many cases of running more trains upon certain lines already overcrowded with traffic. It has already been stated that the chief advantage of electric working lies in its economy when used for light traffic with short headway; but since the conditions of block signalling impose a practical minimum of time between trains, it follows that as soon as this limit is reached the running of more trains would simply lead to incessant delays or signal stops, and an enormous waste of power on the line in constantly starting and stopping between, as well as at, stations. There seems little doubt that automatic electric signalling, such as that adopted on the Liverpool line, would allow of a much shorter headway between trains than the usual method of hand-signalling; but there also seems little doubt that the Board of Trade would regard as quite impossible the use of such a system for lines upon which trains from outside companies possess and exercise running powers.

If London resembled New York, and were provided with a system of isolated lines—overhead or underground—there would be no difficulty at all in the matter from a technical point of view; and the operation of such a system by electricity would doubtless prove both efficient and economical. As it is, the Metropolis has been burrowed through and through in half-a-dozen places with lines, not only interconnected, but each and all joined up for traffic purposes with the great trunk lines radiating outwards. And most valuable connections these are, more especially for goods traffic, though, as we shall see later on, they serve in no small degree for passenger transit also.

(To be continued.)

THE USE OF SMALL ELECTROMOTORS.

Mr. W. Rechniewski writes in *L'Electricien* on the subject of the employment of electromotors in towns. He states that although the use of electromotors is becoming more and more frequent, the development thereof in towns is not what it ought to be. The causes are various and have often been discussed. The principal rival to the electromotor for small power in towns is the gas-engine. If the site is not of great importance, the price per horse-power hour settles the selection of the motor. It is seldom that the motor is wanted to work to its full power, or all the working day.

Apart from theory, it is as well to give a concrete fact. A Paris manufacturer adopted an electromotor of 4½ h.p. instead of a gas-engine of equal power. The difficulties were considerable. The motor had to work at a voltage of 440 volts and at 700 revolutions only, intermediary shafting having been found inadvisable.

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Mr. Rechniewski gives the following figures of the expense per hour for a 4½-i.h.p. gas-engine:

	Running empty.	Full load.
(1) Gas consumed:		
1,800 litres per hour	·54f.	—
2,400 „ „ „	—	1·35f.
(2) Oil	·12f.	·12f.
(3) Maintenance	·13f.	·13f.
(4) Redemption in 10 years and interest at 5 per cent.	·199f.	·199f.
Total	·989f.	1·799f.

For the electromotor receiving current at ·45f. per 736 watts, the following results were obtained:

	Running empty.	Full load.
(1) Energy consumed:		
350 watts at ·061	·213f.	—
3,900 watts at ·061	—	2·379f.
(2) Oil	·001f.	·001f.
(3) Maintenance	·020f.	·020f.
(4) Redemption in 10 years and interest at 5 per cent	·099f.	·099f.
	·333f.	2·499f.

To sum up, the expenses per hour were:

	Running empty.	Full load.
Gas-engine (at 30c. per cubic metre)	·989f.	1·799f.
Electromotor (at 45c. per 736 watts)	·333f.	2·499f.

Consequently at full load the gas-engine is more economical. But as in most cases the power is only used to the extent of about 66 per cent. of the full output of the motor—the electromotor is preferable.

ELECTRICITY METERS.*

BY R. P. WILSON.

In this paper great care has been taken to eliminate as far as possible the historical element, and while the author is anxious to give unsuccessful inventors every credit for their efforts which have largely assisted in the production of the few meters which may be said to be commercially alive at the present day, he has confined himself to the description of the few that represent the survival of the fittest. When the system of charging for electricity at so much per lamp per annum was tried it was found to result in endless dissatisfaction, and now no "undertakers" would dream of charging, except under very special circumstances, and no "consumer" would dream of paying, for his current on the contract system. As specified by the Board of Trade, the duty of an electricity meter is to ascertain and integrate the quantity of electrical energy (E × C) supplied to an installation. Many engineers, however, are content to use ampere-hour meters, and to assume that the voltage on their mains is constant; whereas the author is given to understand that in some cases this cannot be relied on even with that degree of certainty which has been attained by gas lamps when there is water in the pipes.

The earliest form of meter used was that designed by Edison, in which a portion of the current to be measured passed through a cell containing a solution of sulphate of zinc in which are immersed a positive and negative electrode, both of zinc, the current being measured by weighing the plates at intervals, and thus ascertaining the weight of metal transferred from one plate to the other. After each measurement or meter reading the poles are reversed, and the metal deposited is transferred back to the original positive plate, which now becomes the negative electrode of the cell. It was found, however, that the back E.M.F. of the cell varied with the temperature, so that it became necessary to compensate for the error thus introduced. This is effected by inserting in series with the cell a small copper wire resistance whose value varies with the temperature, whereas the resistance of the cell varies inversely as the temperature, so that the resultant resistance remains practically constant. The larger part of the current passes through a German-silver resistance, forming a shunt across the cell—in fact, only ·025 of the whole current is measured, so that any error in the chemical balance used to weigh the amount of metal deposited is multiplied enormously; and though this is a serious objection to the principle, this meter is still very largely used abroad, but only to a very moderate extent in this country. A further difficulty is that the electrolyte in the cell is liable to freeze; to obviate this, a double metal strip, consisting of two metals whose temperature coefficients are different, is introduced. The two metals are fixed together at both ends, and supported at one end only; under the other end is an adjustable contact screw, so arranged that when the temperature falls below a predetermined point, and alters the curvature of the double metal strip, it makes contact with the screw, and by doing so completes the circuit of an incandescent lamp, the heat of which is sufficient to maintain the necessary temperature in the meter case. In cold climates this is, of course, an insuperable objection to the use of the meter, as the station would be called upon to supply current for a number of lamps for which they would, of course, receive no revenue.

Another form of electrolytic meter was devised by Messrs. Lowrie, Hall, and Kolle for use on an alternating current, and consisted of an accumulator in series with the customer's transformer. The effect of this is, of course, to add two volts to the E.M.F. of the positive side of the alternation, and to diminish those of the negative side by a similar amount; the whole current to be measured passed through the accumulator and the electrolytic bath was acted on by the two volts passing continuously in one direction, the current passing through it, and consequently the metal deposited, being, of course, proportional to the lamps alight. It will be seen that if any lamps are left turned on when the primary of the converter is switched off, the accumulator continues to discharge through these lamps, and the electrolytic action in the meter cell continues. The necessity of using a chemical balance to ascertain the consumption of energy in a consumer's premises is very inconvenient, and the consumer himself is not always provided with that childlike faith which is so essential when he cannot take his own meter readings. It is now an axiom that meter dials shall be so constructed that they do not require interpretation by an expert. The above are the only two electrolytic meters which have been used commercially; others have been invented, but their existence has been ephemeral.

The meters most largely used in this country now are the following: (1) the Aron ampere-hour and watt meters, direct and alternating; (2) Thomson-Houston wattmeter, direct or alternating; (3) the Shallenberger ampere-hour meter, alternating only; (4) the Ferranti ampere-hour meter, direct current; (5) the Chamberlain and Hookham direct-current ampere-hour meter. This order approximately represents the extent to which the various types are in use.

(1) *The Aron Meter*, designed by Dr. Aron, of Berlin, was the first practical meter exploited, and many a central station owes a great deal to Dr. Aron. This meter is of the independent motor type, and has gone through many modifications. It consists now of two clocks mounted together on one common base, each driving one wheel of a differential gear; between these two bevel wheels is a third, which gears with both, but which, being free to revolve on its axis, communicates no motion to the dials so long as the two clocks are absolutely synchronous. Of the two pendulums, one is provided with a weight in the ordinary way, and its only duty is to beat seconds with constant regularity; the other is provided with a weight in the form of a permanent magnet in the direct-current ampere-hour meters, or a fine wire coil in the case of the wattmeters. In the first case, the permanent magnet (which beats seconds) normally oscillates over the end of a solenoid in series with the circuit whose consumption is being measured, and the value of each of its beats varies in proportion to the current passing through the solenoid. In the second case (the wattmeter), the permanent magnet is replaced by a fine wire coil oscillating through a solenoid; the resultant effect on the pendulum is proportional to

* Paper read before the Northern Society of Electrical Engineers, April 9, 1894.

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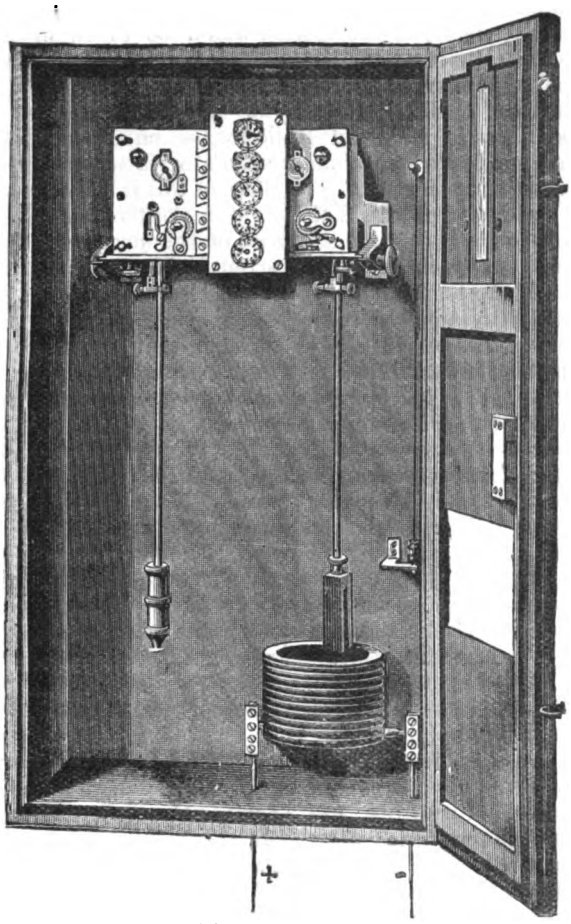
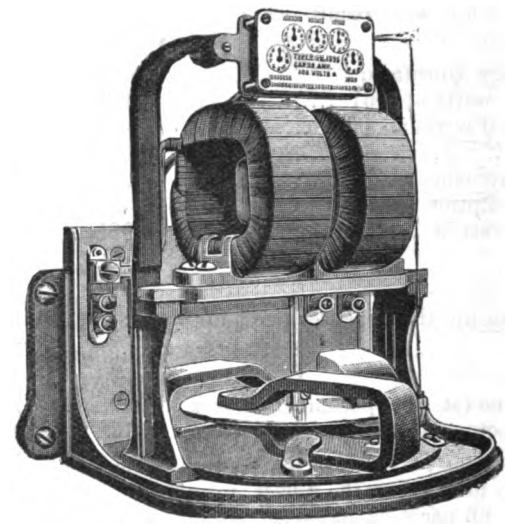
$C \times c$, or $C \times E$, because c varies, of course, with the E.M.F. The principal difficulty these meters present is in keeping the clocks synchronous. Several modifications have been introduced from time to time to effect this; the one most frequently used consists of a loose thread attached to both pendulums carrying a small weight in the middle. But the difficulty has been entirely obviated in a modification introduced by Mr. Miller, of the Kensington and Knightsbridge Company, in which the second clock is dispensed with entirely. The one clock drives a copper disc whose speed is retarded by the current in the series coil before which it revolves. Mr. Miller is also responsible for another very ingenious modification of this meter, which, by making its curve the same going backwards or forwards, enables it to be used to ascertain the efficiency of a secondary battery, and practically the energy it contains at any period of its discharge, by enabling the meter to reduce its reading during the discharge by revolving in the opposite direction.



The Aron Meter.

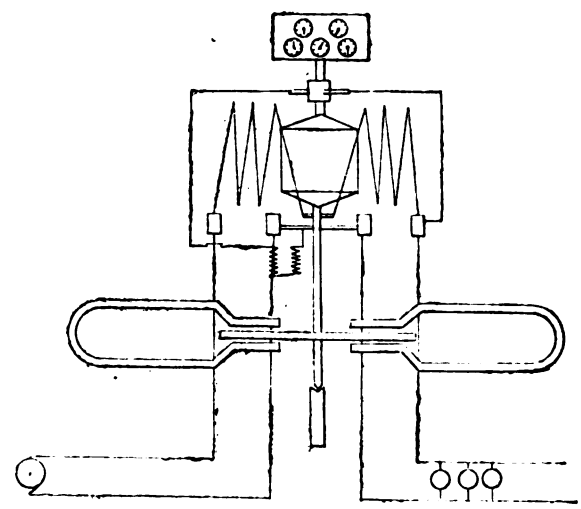
Before leaving these meters it may be well to draw attention to the Oulton-Edmondson meter, which, although not very largely used in this country, has many points in its favour. Like the Aron, it consists essentially of two pendulums vibrating in unison until interfered with by the retarding influence of the series coil, but the mechanism driving these pendulums is electrical throughout; their unison being maintained by communicating the vibrations of one to the other by means of a rigid bar in place of the thread and weight referred to above. The total consumption of each of these meters is two watts per hour, and they have some advantages over the Aron in that they do not require winding or an expert watchmaker to set them up and keep them in repair, and their pendulums do not vibrate except when current is being used.

(2) *The Thomson-Houston Wattmeter.*—This instrument is one whose invention has been claimed by a large number of professors and others, but was presumably originated practically by Prof. Elihu Thomson. It consists of a motor wattmeter whose armature has a vertical shaft extending through the series coil top and bottom, and communicating with the registering mechanism above, and carrying a copper disc at the bottom. This disc revolves between the poles of three permanent magnets. This combination forms a dynamo with a short-circuited armature whose Foucault currents, by reacting on the field magnets generating them, produce a retarding effect on the armature shaft which is proportional to its speed, so that the ultimate speed of rotation is directly proportional to the torque represented by $C \times c$. This is, of course, only correct assuming that the effect of friction has been eliminated. To do this, the amount of friction has been reduced to a minimum by having a jewelled bearing mounted on a spring at the bottom, and a guide only at the top; and its effect, which may be taken to be constant for all speeds, has been counteracted by allowing the armature



The Thomson Meter.

current to pass through the series coil first, so that at all times the initial torque is such that the friction error is negligible. This meter may be used indiscriminately on direct and alternating currents as the added resistance in series with the armature is a very large proportion of the whole, and is wound non-inductively, so that up to about 130 periods per second the self induction may be neglected, as a matter of fact, in practice, if it is found that the difference in the constant of the meter when used on a direct current and on a circuit of 130 periods is less than 1 per cent. They are also constructed for three and five wire circuits. The connections are respectively as follows:



Thomson-Houston Meter—Connections on 2-wire Circuit.

The action of the former is simple enough. Each of the series coils exerts a torque corresponding to $C/2 \times c$, but it must be remembered that c is $= 200/r$, whereas C is $= 100/R$. The five-wire meter is rather more involved, because it will be seen that the current in the coils B and C may be travelling in either direction. The result under any given circumstances may be best demonstrated by taking an example. Let total E.M.F. = 400 volts, and let us assume that the current in each of the five conductors is as follows: A 100, B 25, C 25, D 25, and E 25 amperes. The 25 amperes in B is opposing the meter's rotation in

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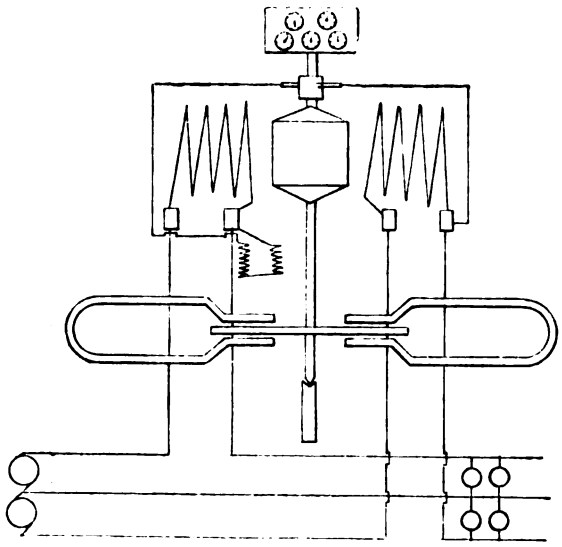
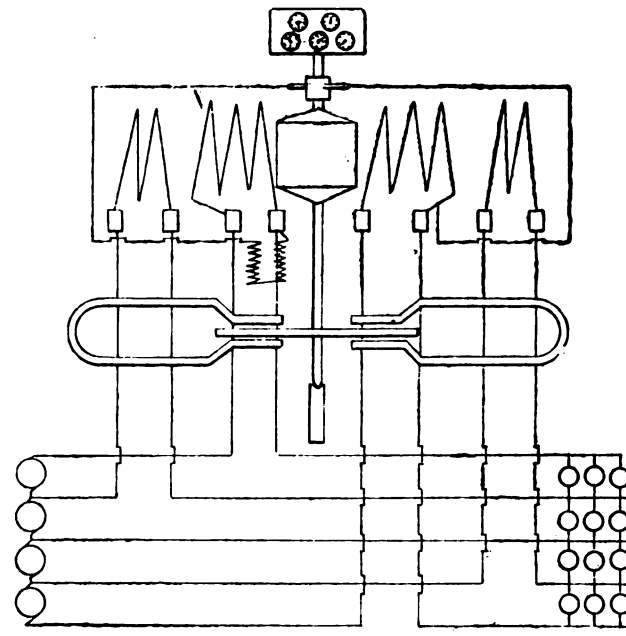
the direction of the torque produced by A C, D C, and E C, so that it will ultimately register (A C/2 – B C/1 + D C/1 + E C/2), c being, as before, proportional to the whole potential difference between A and E—that is to say, the total watts coming out of the station = (100/2 – 25/4 + 25/4 + 25/2) 400 = 25,000.

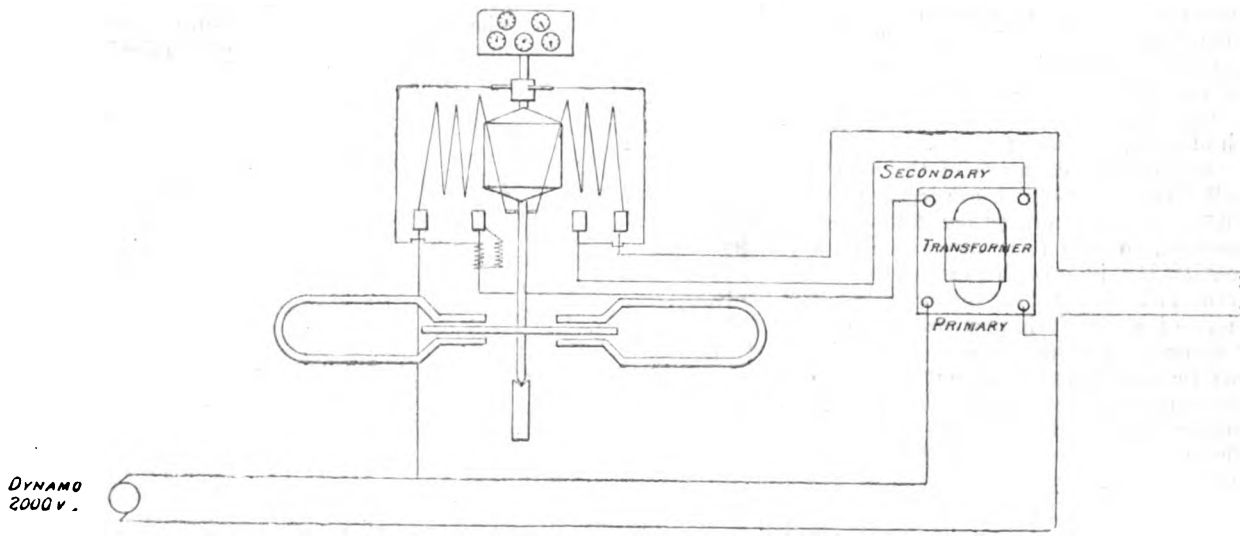


Thomson-Houston Meter—Connections on 3-wire Circuit.

sent out of the station, that Dr. Fleming's anticipations are very nearly realised. In a paper read before



Thomson-Houston Meter—Connections on 5-wire Circuit.



Thomson-Houston Meter—Primary of Alternating System.

Thomson-Houston Primary Meter.—This instrument is one with which most of you are already familiar, and consists of an ordinary Thomson-Houston meter, such as has already been described, having the series coils specially insulated to allow of its being used on a high-tension circuit. The volts for the shunt coil are reduced from 10,000 or 2,000, whatever they may be, to 50, by means of a transformer, and this combination, although claimed by several people, was originally suggested and used by Prof. Elihu Thomson to measure the true watts coming out of alternating-current stations so long ago as 1888 experimentally, and was put on the market commercially in 1889. The use of the transformer does not interfere with its accurate registration, for the reason that the current absorbed by the shunt coil is so small in proportion to the out put of the transformer that the lag in its secondary current is 180deg. behind the primary E.M.F., or, in other words, to all intents and purposes coincident with it: so that at any given moment C × c gives true watts, as the registrations are not those of the mean current multiplied by the mean E.M.F. The importance of this is so self-evident in a high-tension station, either with the transformers banked or in customer's premises, that it requires no comment; and it is interesting to be able to state from the actual experience of a large number of central-station engineers who are using these meters, to ascertain practically the ratio between the apparent and true watts the Society of Electrical Engineers in London, he stated that the apparent would be about 14 per cent. higher than the true watts; as a matter of fact, in practice this figure varies, but it is generally in the region of 12 per cent.

(To be continued.)

OVERHEAD CONTACT ARRANGEMENT — GENOA ELECTRIC TRAMWAY.

Last week we gave (see page 403) some details of the electric tramway carried out in the spring of 1893 by Messrs. Siemens and Halske, of Berlin, along one of the main thoroughfares in Genoa, and an account of a Swiss firm which had obtained concessions for this development in electric traction locally.

As, however, the particulars there given were perhaps insufficient for the purpose of presenting an accurate account of the special features worth noticing in connection with the line and system employed, we now append an illustration to show the type of overhead contact employed, from which it will be seen that a wide departure from the ordinary "trolley" system has been taken. The actual travelling contact consists of the upper side of a rectangular frame supported by two tubular uprights. It is formed of

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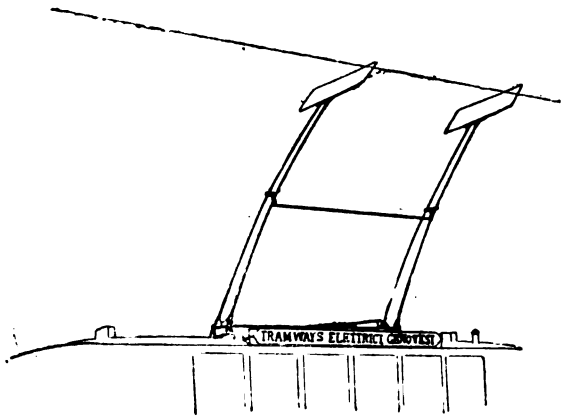
a special metallic compound, and is easily renewable when worn. It presses against the *under* side of the overhead conductor or line wire (not the *top* side, as we were made to say last week by a printer's error), strong spiral springs being used to keep the surfaces in contact. These springs are attached by one end, as shown, to the bottom of the uprights, the other end being fastened to the roof frame of the car. Two contact bars and frames are provided for each car, mounted on the roof, as shown in the illustration.



The advantages claimed for this method of drawing current from the line wire are, briefly, the following. In the first place, a much greater degree of reliability in maintaining contact is secured as compared with the "trolley" system, and obviously there is not the same danger of continually jumping away when the car oscillates endwise—or "teeters," as the Americans say. Moreover, the contact bar is made of a length almost equal to the width of a car, so that ample swing is allowed for.

In the second place, much of the overhead straining or pull-off wires are rendered unnecessary at curves since the conductor or line wire need not follow the rounded curve of the rails, but can form a chord across, since the length of contact bar is enough to preserve contact, although at different points as the car moves round. This advantage becomes of no small importance when it is remembered that in many cases the only serious objection to the use of electric tramways on the overhead-wire system lies in the ugly and unæsthetic appearance of the numerous wires—conductor and supporting—at the curves. Any method which avoids this objectionable feature deserves strong recommendation.

POLYPHASE TRANSMISSION.*

BY CHARLES F. SCOTT.

(Concluded from page 410.)

Advantages of Three Phases.

In transmission it has been recently emphasised by a good many people that the single-phase system and the two-phase system require the same weight of copper, and that the three-phase three-wire system requires 25 per cent. less for transmitting power under similar conditions, with the same maximum E.M.F. This places an advantage on the side of the three-phase system, which in many cases is of very considerable importance. The aggregate advantage, however, is greater than 25 per cent. A two-phase system laid out for the greatest economy requires that the interest on the cost of conductors shall equal the cost of the power lost. If the three-phase system be substituted the loss may remain the same, and the copper will cost 25 per cent. less. This does not give the best relation between cost of copper and loss of power, so that a more economic adjustment is evidently possible.

It has also been shown that the self-induction of a three-phase three-wire circuit for transmitting under similar conditions of E.M.F. is only 57 per cent. of that which is incident to the two-phase four-wire circuit. When the power factor is high, the effect of self-induction of line upon regulation varies approximately as the square of the counter E.M.F. The drop due to the self-induction of a three-phase circuit is therefore only about one-third of a single-phase or two-phase circuit. This is a second advantage for the three-phase system which is of great value. A further advantage of three wires instead of four wires is the reduced cost of insulators and pole construction, the reduced losses due to leakage, etc.

Advantages of Two Phases.

An important point of difference between the two systems is the effect of loading one branch of the system more heavily than the others, as is common in incandescent lighting. One of the statements which remain uncontroverted in Prof. Forbes's recent comprehensible and remarkable paper upon the "Electrical Transmission of Power at Niagara Falls," is in reference to the difference of regulation in dynamos for two-phase and for three-phase alternating currents. He gives the result of tests showing that the circuits of a three-phase generator differ greatly in pressure if they are not equally loaded, and states that, having considered these points, the directors of the company determined to reject the three-phase system. These results agree fairly well with tests which I have made. The relative regulation of the two types of machine depends very largely, of course, upon the character of the construction. Although it is not just to condemn one system because a certain construction is bad, yet the theoretical and practical tendencies toward the evil are largely removed by discarding the three-phase type.

If independent regulation of circuits is necessary, one circuit can be given the proper pressure directly from the dynamo, and the other circuits may be raised or lowered as may be required. This involves apparatus for regulating two circuits if the station be operated by the three-phase system, and only one circuit if the two-phase system is in use.

In a system where incandescent lighting is to be a prominent feature, or where load of any kind may be required upon one circuit and not on the other, the two-phase system has therefore a decided advantage in station regulation over the three-phase system. Another advantage of a two-phase circuit is that the load is separated into two divisions instead of three divisions, which is in general much simpler. A further advantage of the two-phase is in the reduction of potential for motors, Two transformers are sufficient in the two-phase system. whereas three transformers are commonly used in the three-phase system. The two transformers which would be required for small motors will cost considerably less than the three transformers which would be required on the three-phase system, and the loss in transformation will be much less, as there is not much difference in the cost of small transformers of slightly different sizes, and the large sizes are more efficient. The ease and simplicity of installation is also a gain for the two-phase arrangement.

A New System.

In considering the marked advantages of the two-phase system for distribution and of the three-phase system for transmission, it occurred to me that a combination of the two systems might secure the advantages of both in a combined system, and I have worked out a simple and effective method of accomplishing this result. It is well known that if two E.M.F.'s differing in phase be connected in series that the resulting E.M.F. will in general differ in value and in phase from either of its components. If two E.M.E.'s differing in phase 90deg. be connected in series, the resultant E.M.F. is represented in direction and magnitude by the hypothenuse of a right-angle triangle of which the two sides are the two component E.M.F.'s. Thus, in Fig. 14, if A O and O B are two E.M.F.'s at right angles, and these E.M.F.'s be connected in series, the resultant is the line A B of different phase from either of the components. It is a simple matter to so proportion the components that O B is equal to one-half of A B, as shown in the diagram. In a similar manner it is readily seen that the same E.M.F. O A may be combined with O C, which differs from it by 90deg. (but is equal and opposite to O B) in such a way as to give A C equal to A B, but differing in direction. B O and O C added together give B C. The

* Paper read before the National Electric Light Association, Washington

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E.M.F. B C may, therefore, be combined with the E M.F. A O at right angles to it in such a way as to give additional E.M.F.'s A B and C A, which, in connection with B C, give three equal E.M.F.'s 120deg. apart. This is the relation of E.M F.'s on the three-phase system.

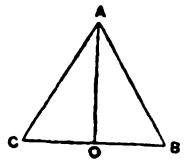

FIG. 14.

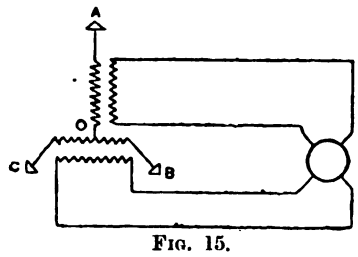

FIG. 15.

The application of this arrangement to transformers is illustrated in the accompanying Figs. 15 and 16. The

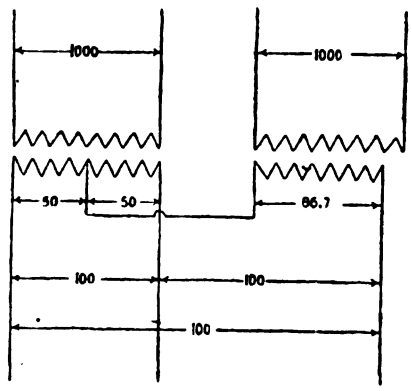

FIG. 16.

primaries of two transformers are connected to a generator giving two-phase current. The secondary E.M.F.'s, there fore, differ 90deg. One secondary is made equal to 100 turns, and a loop is brought out at its middle point, giving 50 turns at each side. The second secondary has 87 turns, which is approximately equal to 50 multiplied by the square root of 3. One end of the secondary circuit is connected with the middle point of the secondary of the first transformer, as shown, and the three free terminals will then deliver E.M.F.'s differing in phase 120deg. If the E.M F. on each primary be 1,000 volts, and on one secondary 100 volts, and on the other 87 volts, then the E.M.F. measured between any two secondary terminals will be 100 volts.

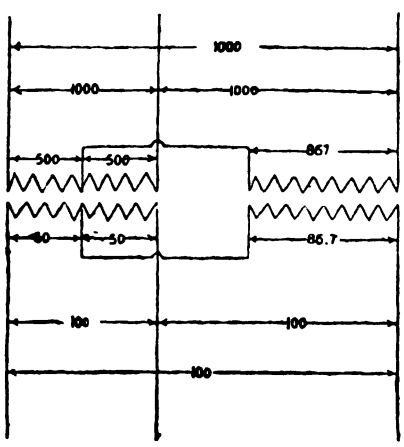

FIG. 17.

This three-phase circuit is adapted for operating three-phase motors. In a system of transmission, two-phase currents at the generator may be converted into three-phase currents, as shown in Fig. 18, and the windings may be such that the E.M.F. is raised for transmission. The currents are then transmitted by three phases, effecting economy in copper. At the other end of the line a similar arrangement of transformers may be used for converting from the three-phase to the two-phase system. The two-phase currents may then be used for the operation of two-phase motors, or the circuits may be independently loaded with lamps, or otherwise. If lamps be placed on the transformer, which supplies directly from its two terminals, the transmission is directly from the generator, without affecting in any way the other circuit, as the generator terminals are connected directly to the first primaries, and the secondaries of the raising transformer are connected directly to the primaries of lowering transformer, and the current from this is taken directly to the load. On the other hand, if the other circuit be loaded, the action here will also be on its own generator circuit without affecting the first. The current from the raising transformer in this circuit passes to the middle of the secondary of the other transformer, where it divides and flows in parallel through the two parts of the coil and two of the lines. As one-half of the current flows through each part of the secondary coil in opposite directions, the self induction is completely neutralised, and the transformers in this circuit are independent of the operation of the other circuit. It is to be noted that under this condition the line E.M.F. delivered by this transformer is only 87 per cent. of that delivered by the first transformer. The lower E M.F., however, is compensated for by the fact that the current on one side is passed through two of

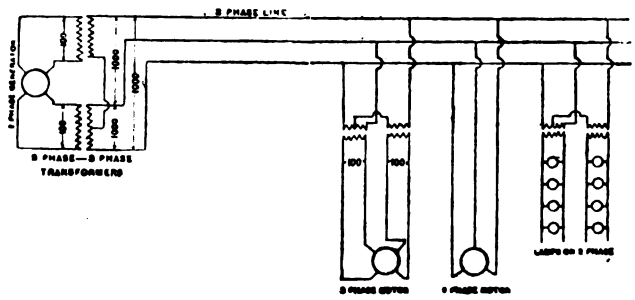

FIG. 18.

the lines in parallel, thus reducing the resistance of the circuit and compensating for the slightly lower E.M.F.

The effect upon the regulation of the generator when two-phase circuits at the end of a three-phase transmission line are independently loaded is found, both by theory and test, to be the same that prevails when the load is placed directly upon the corresponding circuit of the generator. A modification of this system is found in the arrangement where the three-phase current is produced in the generator and transmitted over three wires to the reducing transformers. These transformers may be arranged as described for producing two phases (Fig. 19). Loads may be placed upon either of the two-phase circuits, and practically the same regulation in the generator will result that would have resulted if the generator itself had been wound for two phases and one of these circuits loaded. In this way it is possible to place lighting load upon a three-phase

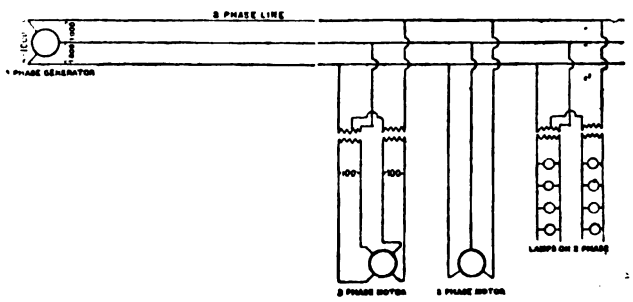

FIG. 19.

generator in two instead of three units, and to avoid the bad regulation in the generator due to unequal loading.

A similar arrangement of two transformers may be used for converting three phases of one potential into three phases of another potential. This arrangement is shown in the accompanying Fig. 17.

The efficiency of two transformers arranged for converting from two-phase to three-phase is reduced below that when working independently on ordinary loads by an insignificant amount. If the efficiency in ordinary working is, say, 97·5 per cent., it would be reduced to 97·4 per cent. in converting from one number of phases to the other.

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The Tesla polyphase system, in which the largest electrical enterprises are seeking a realisation, adapts itself with marvellous facility, not only to all branches of electrical industry, but also by the transformation of its phases to the utilisation of three phases for gaining the highest economy in transmission, and of two phases for securing the maximum advantages in distribution.

THE NATIONAL ELECTRIC LIGHT ASSOCIATION'S STANDARD RULES FOR ELECTRICAL CONSTRUCTION AND OPERATION.

We reproduce below the standard code of rules* issued by the National Electric Light Association. These rules were revised and adopted at the seventeenth convention held at Washington on February 27 and 28 and March 1 and 2, 1894:

CENTRAL STATIONS.

CLASS A.—FOR LIGHT, HEAT, OR POWER.

1. These rules also apply to dynamo-rooms in isolated plants, connected with or detached from buildings used for other purposes. Also to all varieties of apparatus of both high and low potential.

2. The floors of central stations should be cleaned thoroughly at least once a week, and especial care taken that oil is not thrown from the machinery, as floors and machinery saturated with oil increase greatly the fire risk.

3. Oil, waste, and such supplies should not be kept in the loft or cellar, and where it is impossible to remove them to a separate building automatic sprinklers must be installed.

Generators or Motors.

1. Must be located in a dry place.

2. Must be insulated on floors or base frames, which must be kept filled to prevent absorption of moisture, and also kept clean and dry.

3. Must not be exposed to flying or combustible materials.

4. Must each be covered with a waterproof cover when not operating.

5. In no case must a generator be placed in a room where any hazardous process is carried on, such as the working-room of a cotton, jute, flax, woollen, or flour mill.

Care and Attendance.

1. A competent man must be kept on duty in the room where generators are operating.

2. Oily waste must be kept in metal cans, and removed daily.

Conductors.

From generators, switchboards, rheostats, or other instruments, and thence to outside lines, conductors:

1. Must be in plain sight.

2. Must be wholly on non-combustible insulators, such as glass or porcelain.

3. Must be separated from contact with floors, partitions, or walls through which they may pass by non-combustible insulating tubes.

4. Must be kept rigidly so far apart that they cannot come in contact.

5. Must be covered with non-inflammable insulating material sufficient to prevent accidental contact.

6. Must be ample in carrying capacity to prevent heating. (See capacity of wires table.)

7. Must be connected by splices or joints equal in carrying capacity to the conductors themselves, soldered to make them efficient and permanent.

8. Must be, when under floors or in distributing towers, placed in spaces ample for inspection and ventilation, and provided with special insulating covering.

Switchboards.

1. Must be so placed as to make it impossible to communicate fire to surrounding combustible material; accessible from all sides when the connections are on the back; or may be placed against a brick or stone wall when the connections are entirely on the face.

2. Must be kept free from moisture.

3. Must be made of non-combustible material, or of hard wood, filled to prevent absorption of moisture.

4. Must be equipped with bars and wires in accordance with Rules 1, 2, 3, 4, 5, 6, and 7 for placing conductors.

Resistance Boxes and Equalisers.

1. Must be equipped with metal or non-combustible frames.

2. All rheostats for controlling dynamos, motors, or devices for electric heating and cooking should be constructed entirely of non-combustible materials.

3. Must be treated as sources of heat.

4. Must be placed on the switchboard, or a distance of a foot from combustible material, or separated therefrom by asbestos or cement.

Lightning Arresters.

1. Must be attached to each side of every overhead circuit connected with the station.

2. Must be in plain sight.

3. Must be on the switchboard, or in an equally accessible place, away from combustible material.

4. Must be connected with at least two earths by separate wires not smaller than No. 6 B. & S. gauge.

5. Must be so constructed as not to maintain an arc after the discharge has passed.

Testing.

1. All series and alternating circuits must be tested every two hours while in operation, to discover any leakage to earth abnormal in view of the potential and method of operation.

2. All multiple arc low-potential systems (300 volts or less) must be provided with an indicating or detecting device, readily attachable, to afford easy means of testing where the station operates perpetually.

3. Data obtained from all tests must be preserved for examination by insurance inspectors.

CLASS B.—ARC (SERIES) SYSTEMS.

Outside Conductors.

All outside overhead conductors (including services):

1. Must be covered with some insulating material not easily abraded.

2. Must be firmly secured to properly insulated and substantially built supports, all the wires having an insulation equal to that of the conductors they confine.

3. Must be so placed that moisture cannot form a cross-connection between them, not less than 1ft. apart, and not in contact with any substance other than proper insulating supports.

4. Must be at least 7ft. above the highest point of flat roofs and at least 1ft. above the ridge of pitched roofs over which they pass or to which they are attached.

5. Must be protected, whenever necessary, in view of possible accidents to conductors or supports, from possibility of contact with other conducting wires or substances to which current may leak, by dead insulated guard irons or wires. Special precautions of this kind must be taken where sharp angles occur, or where any wires might possibly come in contact with electric light or power wires.

6. Must be provided with petticoat insulators of glass or porcelain. Porcelain knobs, cleats, and rubber hooks are prohibited.

7. Must be so spliced or joined as to be both mechanically and electrically secure without solder. They must then be soldered to ensure preservation, and covered with an insulation equal to that on the conductors.

8. The following formula for soldering fluid is approved:

Saturated solution of zinc	5 parts.
Alcohol	4 ,,
Glycerine	1 ,,

9. Conductors should not be run over, or attached to, buildings other than those in which light or power is being or is to be used, but on separate poles or structures always easily inspected.

Service Blocks.

1. Must be covered over their entire surface with at least two coats of waterproof paint, and so maintained.

2. Telegraph, telephone, and similar wires must not be placed on the same arm with electric light or power wires, and should not be placed on the same structure or pole.

INTERIOR CONDUCTORS.

All Interior Conductors.

1. Must be, where they enter buildings from outside terminal insulators to and through the walls, covered with extra waterproof insulation, and must have drip loops outside, preferably slanting upward toward the inside, and bushed with waterproof and non-combustible insulating tube.

2. Must be arranged to enter and leave the building through a double-contact service switch, which will effectually close the main circuit and disconnect the interior wires when it is turned "off." The switch must be so constructed that it shall be automatic in its action, not stopping between points when started, and prevent an arc between the points under all circumstances; it must indicate on inspection whether the current be "on" or "off," and be mounted on a non-combustible base in a position where it can be kept free from moisture and easy of access to police or firemen.

3. Must be always in plain sight, never covered, except in special cases, where an armoured tube may be necessary.

4. Must be covered in all cases with a waterproof non-combustible material that will adhere to the wire, not fray by friction, and bear a temperature of 150deg. F. without softening.

5. Must be in dry places kept rigidly apart at least 10in., except when covered (in addition to insulation) by waterproof, non-conducting, and non-inflammable tubing, which must be strong enough to protect the insulating covering from injury. Conductors thus placed may be run not less than 3in. apart, and be fastened with staples, under which are placed mechanically rigid insulating strips or saddles of greater width than the metal of the staple, by which possibility of injury to the tube may be prevented

6. Must be in damp places attached to glass or porcelain insulators, and separated 10in. or more.

7. Must be, when passing through walls, floors, timbers, or partitions, treated as in central stations under like conditions.

* *Notice.*—These rules are subject to amendments or alteration, and will be modified from time to time as experience and the exigencies of electrical development demand. All such changes shall receive the official sanction of the National Electric Light Association, and be given immediate publicity upon their adoption.

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LAMPS AND OTHER DEVICES.

Arc Lamps.

1. Must be carefully isolated from inflammable material.
2. Must be provided at all times with a glass globe surrounding the arc, securely fastened upon a closed base. No broken or cracked globes may be used.
3. Must be provided with a hand switch, also an automatic switch, that will shunt the current around the carbons should they fail to feed properly.
4. Must be provided with reliable stops to prevent carbons from falling out in case the clamps become loose.
5. Must be carefully insulated from the circuit in all their exposed parts.
6. Must be, where inflammable material is near or under the lamps, provided with a wire netting around the globe and a spark arrester above, to prevent escape of sparks, melted copper or carbon.
7. Incandescent lamps in series circuits, having a maximum potential of 350 volts or over, must be governed by the same rules as for arc lights, and each series lamp provided with a hand switch and automatic cut-out switch; when lights are in multiple series, such switches and cut-outs must not control less than a single group of lights. Electromagnetic devices for switches are not approved.
8. Under no circumstances will incandescent lamps on series circuits be allowed to be attached to gas fixtures.

(To be continued.)

ELECTRIC RAILWAYS.*

The science of electricity is rapidly developing as an aid to locomotion, and though already a great deal has been done to demonstrate the practical use to which electrical power can thus be put, there is yet much room for future improvement. . . . The comparative cheapness with which tunnelling can now be carried out by means of the Greathead system has also given an important impetus to the underground electric railway as a promising enterprise. For example, the City and South London Railway, which has now been in working order over three years, cost rather under £300,000 per mile to construct and equip, compared with £1,000,000 per mile, the cost of the City lines of the District and Metropolitan Companies. The City and South London has really done a great public service, by demonstrating that electricity can be used as the means of efficiently working an underground railway. Unfortunately, it has not as yet been an altogether profitable undertaking so far as its shareholders are concerned, but of course, as a pioneer, it has had exceptional difficulties to overcome. It is, however, gradually improving its position from the investor's as well as the public point of view. Of course, the working of this line, since its opening in December, 1890, has been watched with great interest, and the experience gained thereby should prove of great benefit in the case of projected undertakings of a similar nature. It may be of interest to deal with some of the features of the City and South London Company, in view of the interest aroused in the investor's mind regarding electric railways. During the first year's working it carried 5,161,000 passengers, and ran about 350,000 train miles over its three miles of railway. In 1893 it carried 6,240,007 passengers, and ran 441,765 train miles over the same length of railway. The receipts increased from £39,201 to £44,526, and the net revenue from £8,908 for 1891, to £16,310, so that, in spite of a large increase in passengers carried and revenue earned, expenses declined considerably. The proportion of working expenses to gross receipts is still high, however. For the year 1893 expenses swallowed up 65 per cent. of the revenue. This contrasts with a percentage of 40 in the case of the Metropolitan, and 45 in the case of the District Company for working expenses. This higher ratio in the case of the City and South London compared with the old underground system is due to the smaller amount earned per train mile run; whilst, on the other hand, the cost of running is practically the same per train mile as in the case of the Metropolitan and District Companies—namely, sixpence. For 1893 we find the electric railway earned only about 2s. per train mile run, compared with 6s. in the case of the other companies; and as in all three cases the actual cost of running per train mile is 6d. this accounts for a good deal of the difference in ratio of working expenses referred to, and, of course, the ultimate effect is to nullify the advantage the electric railway possesses in the matter of capitalisation. The item of working expenses referred to is being reduced, however, considerably, and for 1893 it showed a reduction of £800 compared with 1892, though the train mileage run increased over that year by 38,400 miles. At the present time the ordinary stock, representing £630,000 out of the total capital of £862,000, receives a dividend of only 13s. 9d. per cent., so that a great deal of leeway has to be made up before the City and South London can be called a profitable venture for its shareholders. The next scheme for an electric railway was the Central London, which in 1891 received parliamentary sanction to construct a line from Shepherd's Bush to Cornhill. The next session of Parliament saw quite a host of applications for underground electric railways, including the Charing Cross, Euston, and Hampstead, Baker-street and Waterloo, Waterloo and City, Great Northern and City—all new schemes—and applications were also made by the two companies already incorporated for extensions of their systems. The City and South London sought powers to build a line connecting its present line south of the Thames with The Angel, at Islington; and the Central London applied for parliamentary sanction to the extension of its proposed line from the Bank to Bishopsgate All these schemes were submitted to a Joint Committee of the two Houses of Parliament, and, subject to modifications effected in the public interest, all the applications referred to received the sanction of Parliament in 1892 or 1893. Two of the companies referred to—the Waterloo and City, and the Charing Cross, Euston, and Hampstead—have since come before the public for the capital to carry out their schemes, and others will probably not be long in making their appearance.

* From the *Financial Times*.

There can be little doubt that the schemes which have up to the present time received the sanction of Parliament will, when completed, greatly facilitate travelling between many important points in the Metropolis, and do much to relieve the congestion of traffic in the main thoroughfares . . . It is also satisfactory to observe that the routes of the proposed lines are such as would appear to meet the public wants, and as far as the community in general is concerned they will be welcomed as valuable additions to means of communication in the Metropolis. Their prospects as profitable ventures for investors are more dubious, especially in view of the experience of the City and South London line. Nevertheless, the electric railway appears to offer a very good field for enterprise; for future inventions and improvements will no doubt do much to render it more profitable than it can be under existing circumstances. The following is a summary of the schemes for electric railways in the Metropolis which have received parliamentary sanction:

Company.	Capital authorised. Share capital.	Loans.
Charing Cross, Euston, and Hampstead	£1,416,000	£472,000
Waterloo and City	540,000	180,000
Central London	2,850,000	950,000
Great Northern and City	1,500,000	500,000
Baker-street and Waterloo	1,250.000	416,000
City and South London (Islington extension)	750,000	250,000

The first two schemes are those which have already come before the public. In the present session of Parliament the Central London is applying for an extension of the time within which its line is to be completed to the year 1900. The Baker-street and Waterloo is a scheme to connect the South-Western terminus more directly with the West-end, and is a companion scheme to the Waterloo and City, which has been received so favourably. Two of the South-Western directors are on the Board of the Baker-street and Waterloo Railway. It should be mentioned that the Islington extension of the City and South London is authorised as a separate undertaking, and includes powers to make a subway connecting it to the Brighton Station at London Bridge, and another connecting it with the Metropolitan and District Companies near the Monument. More will no doubt be heard of these various schemes before very long.

We have received from a well-informed correspondent the following notes on our recent editorial article, comparing the City and South London Electric Railway with the original underground lines:

"The very interesting and instructive remarks on electric railways, which appeared in your issue of the 9th, open up a very wide question which it would be impossible to exhaust in a volume, much less in a single column. Nearly everything you say will command general acquiescence among competent authorities, and the comparison raised between steam and electric railways is so far-reaching that it may be usefully carried a good deal farther than you have done. The promoters of electric traction may naturally object to the City and South London being selected as the test of their system, and you yourself acknowledge the drawbacks. They are, however, even greater than you have realised. A pioneer line, built under great difficulties, engineering and financial, it has not had, as yet, a fair trial in any sense. It was not even originally designed for an electric railway, but for a cable tramway. To show you how that affects the operations of the road, I need only mention three of the many drawbacks it entailed. The tunnels are smaller and more slightly built than if they had been designed from the outset for their present use—very much smaller than the tunnels on the new lines will be. Their diameter is only 10ft. 6in. against 11ft. 6in. and 12ft. 6in. on the new lines. The rolling-stock is lighter than it should have been, and deficient, not only in numbers, but in carrying capacity. The stations, too, are notoriously inadequate, especially the present terminus at King William-street, which is now being enlarged. The lifts, if they had to be rebuilt, would be made both larger and more powerful.

"But all these defects are trifling compared with the shortness of the platforms, which can only accommodate half trains of two or at most three carriages. In order to get full advantage of the busy hours of morning and evening, the trains ought to have had six or seven carriages. As they are, when traffic is heavy, they can only take a fourth of it, and during the long interval between the busy times they run half empty. Traffic would have been difficult enough for a new road to gather on such a route with two overhead railways, a tramway, and a score or more of omnibus lines running alongside, but the City and South London unfortunately handicapped itself in advance by this inelasticity of its carrying power. That it should, under the circumstances, earn as much as 2s. per train mile is gratifying in itself, and an earnest of better things to come. The authorised extension to Islington—which, by the way, will be a very superior line to the original—should bring a large increase of traffic, which, as you show, is all that the City and South London needs to realise the

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full benefit of its economical system of working. Improved financial conditions will enable it to enlarge its stations, improve its equipment, and in other ways increase its earning power.

"Meanwhile, leaving earnings out of account, there is a very important lesson for railway investors in the comparison of working expenses per train mile, which you give one or two examples of. It is worth following into greater detail, as you will see from the subjoined tables, in which I have calculated the relative cost per train mile of the principal classes of expenditure on the two metropolitan roads and the City and South London:

TRAIN MILEAGE EXPENSES, METROPOLITAN AND SOUTH LONDON RAILWAYS, 1893.

Mileage, 1893.	Metropolitan.		City and South London.	
	—	Train miles, 2,126,841.	—	Train miles, 441,765.
	£	Per mile. Pence.	£	Per mile. Pence.
Maintenance of way—				
June £16,817				
December 18,067	34,884	3·936	1,016	0·551
Locomotive power—				
June £45,428				
December 44,631	88.059	9·936	11,691	6·351
Carriage repairs—				
June £13,651				
December 14,511	28,162	3·177	910	0·494
Traffic expenses—				
June £40,260				
December 41,370	81,630	9 211	11,537	6·267
General charges—				
June £15,350				
December 14,260	29,610	3·341	3,356	1·823
Law and compensation—				
June £3,655				
December 1,904	4,559	0·514	83	0·045
Rates, taxes, and duty—				
June £22,930				
December 23,098	46,028	5·193	1,087	0·590
	£312,932	35·308	£29,680	16·121

TRAIN MILEAGE EXPENSES, METROPOLITAN DISTRICT AND SOUTH LONDON RAILWAYS, 1893.

Mileage, 1893.	Metropolitan District.		City and South London.	
	—	Train miles, 1,204,913.	—	Train miles. 441,765.
	£	Per mile. Pence.	£	Per mile. Pence.
Maintenance of way—				
June £10,461				
December 10,779	21,240	4 230	1,016	0·551
Locomotive power—				
June £23,288				
December 23,895	47,183	9·397	11,691	6·351
Carriage repairs—				
June £7,323				
December 7,592	14,915	2,970	910	0·494
Traffic expenses—				
June £26,169				
December 26,831	53,000	10·556	11,537	6·267
General charges—				
June £10,301				
December 10,533	20,834	4·149	3,356	1·823
Law and compensation—				
June £747				
December 576	1,323	0·263	83	0·045
Rates, taxes, and duty—				
June £13,472				
December 13,479	26,951	5·368	1,087	0·590
	£185,446	36·833	£29,630	16·121

"It is not, of course, strictly fair to measure light trains of two or three carriages against heavy trains of eight or nine carriages; but this affects chiefly the locomotive power, as to which it may be observed that the present engines of the City and South London could haul double their actual loads. In the other items, maintenance of way, traffic expenses, general charges, and even rates and taxes, the advantage of the electric traction over steam is striking and indisputable. Maintenance of way, for instance, is on the City and South London little more than a ½d. per train mile, against close on 4d. per train mile on the Metropolitan, and 4¼d. on the District. The cause of this huge saving is now familiar to every railway engineer. The Greathead tunnel, once completed, is perfectly weatherproof. There is no smoke to corrode it, it needs no painting, and the rails, being fixed to the iron floor of the tube, require no ballasting and relaying. From a similar cause carriage repairs are very slight. Hardly ever exposed to the outside atmosphere, carriages remain clean and wholesome for a long time. Traffic expenses per train mile are low, for the evident reason that with a rapid shuttlecock service, working over a short length of road, many more train miles can be run per mile of road than on the Metropolitan, for instance, with its 52 miles of track to work over. Traffic expenses and general charges combined average, it will be seen, only 8d. per train mile on the City and South London, as compared with nearly 12½d. per train mile on the Metropolitan, and almost 14¾d. on the District.

"The aggregates are no less significant than the details. On the City and South London the whole cost of working, including rates and taxes, is about 16d. per train mile, while on the Metropolitan it exceeds 35d. per train mile, and on the District it almost reaches 37d. The City and South London might treble the weight and the carrying capacity of its trains without approaching the 9½d. per train mile of the District Railway, or the 10d. per train mile of the Metropolitan, while its other expenses would be little, if any, increased. Though by no means a flourishing specimen of an electric railway, it has already scored a strong point for electricity over steam."

TRIAL OF ELECTRIC PUMPING PLANT.

A trial was made in the works of Messrs. Ernest Scott and Mountain, The Close, Newcastle-on-Tyne, on Saturday last, of two sets of large electrically-driven pumps in course of construction for the Lothian Coal Company, Newbattle Collieries, Dalkeith, N.B. The trial was witnessed by a number of leading engineers of the district, as well as by others interested in collieries and electrical matters from a distance. The test proved very successful, and as this electrical plant is probably the largest pumping plant that has yet been put into a colliery electrically driven, it was of more than general interest. The general outline of the machinery is given in the annexed description, which has been forwarded to us by the company.

The installation consists generally of two horizontal engines, each capable of developing 150 effective horse-power with a steam pressure of 100lb. per square inch; two "Tyne" dynamos, each capable of giving an output of 60,000 watts at a speed of approximately 600 revolutions per minute; two electric motors, each of 60 h.p.; two sets of three-throw pumps, each capable of delivering 200 gallons of water per minute against a head of 650ft.; together with conducting cables, etc. Each engine is of the horizontal long-stroke type, fitted with Corliss valve gear in order to obtain the highest possible economy in steam consumption. The engines are fitted with cylinders 15½ diameter by 33 stroke; each engine is provided with an injection condenser worked by an extension of the piston-rod and placed behind the cylinders. By the adoption of the condenser a very considerable economy in steam consumption will be obtained. It is proposed to add two additional engines, making four in all, as soon as the present plant is started; three of the engines will be used for driving three dynamos, the fourth engine being used for driving the screens and other machinery in the colliery. The four engines will drive on to a main countershaft running the entire length of the engine-house; this shaft is fitted with four main driving pulleys for receiving the main driving belts from the engines and four dynamo pulleys for transmitting the power from the countershaft to the dynamos Each of the pulleys are fitted with clutches, so that they can be put in and out of gear as required, and by this arrangement any combination of engines and dynamos can be run as required.

At present two dynamos are being provided for working the two sets of electric pumps; provision, however, is made for four dynamos in all—the extra power will be used for driving additional pumps and haulage and other electrical machinery later on. The two dynamos are of Messrs. Scott and Mountain's improved mining type, each capable of giving an output of 60,000 watts—*i.e.*, 120 amperes at an E.M.F. of 500 volts when running at a speed of 600 revolutions per minute. The armatures are of Messrs. Scott and Mountain's improved type, admitting of perfect ventilation and ready repair in case of accident. The armature cores are positively driven from gunmetal drivers fitting into three keyways in the discs. The commutators are of extra length and diameter to ensure freedom from wear and tear, and are insulated with mica and mounted upon gunmetal sleeves, enabling them to be removed from the machines if required. Cast-iron sliding bed-plates are provided, enabling the slack of the belts to be taken up whilst the dynamos are running.

The main switchboard consists of an enamelled slate base fitted with two colliery switches with carbon sparking contacts, enabling the current to be switched off without any risk of burning the switch. A third switch is provided, so that either dynamo can supply current to either set of pumps. Two ampere-meters and two voltmeters are provided—*i.e.*, an ampere-meter and voltmeter to each dynamo—so that the E.M.F. and current can be measured as required.

The current from the dynamos to the pumps will be conveyed by four cables. The core of each cable consists of 19 wires 15 B.W.G. insulated with a thick coating of bituminised fibre. The cable is then very heavily armoured with galvanised iron wires, the inner armouring consisting of 29 wires No. 11 B.W.G, and the outer armouring consisting of 35 wires No. 11 B.W.G. The cables are made in eight lengths with joints in the centres; these joints are made in junction-boxes, so that they can be readily got at if required.

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The pumps are of the vertical three-throw ram type, each set of pumps being capable of delivering 200 gallons of water per minute against a head of 650ft. when running at a speed of approximately 45 strokes per minute. The pump bodies for each set of pumps consist of three identical castings, interchangeable, and fitted with glands bushed with gunmetal. The suction and delivery valve-boxes are all independent, and fitted with an improved type of valve with double outlet. The connecting pipes are also interchangeable. This arrangement of pumps, valve-boxes, and connecting pipes enables the pumps to be run, assuming an accident should happen to any of the various parts. The rams are of gunmetal 7½in. diameter by 12in. stroke, fitted into cast-steel cross-heads working in slipper guides on the bed-plates. The connecting rods are of steel, fitted with bored and turned brasses at the crank-pin end and double eye with steel gudgeon at the cross-head end. The crankshafts are of the three-throw type, running in four bearings on the bed-plate. The shafts are 5in. diameter, the total length of bearing surface in the main bearings being 24in., and in the crank-pins 18in.

The power is transmitted from the countershaft, which runs in four bearings, to the pumps by means of two pairs of helical spur wheels and pinions, each pair of wheels being capable of transmitting the whole power if required. The motors drive the pumps also by two belts working on to two double-shrouded pulleys on the countershafts; each of the belts are capable of transmitting the whole of the power.

The electric motors are similar in construction and design to the dynamos, and are each capable of developing 60 effective horse-power when running at a speed of 600 revolutions per minute. Two main starting switches are being provided, and will be fixed in the pump-house, so that either set of pumps may be started as required, and the speed also regulated according to the duty which they have to perform.

COMPANIES' MEETINGS.

SOUTHAMPTON ELECTRIC LIGHT AND POWER COMPANY, LIMITED.

The annual meeting of the shareholders of the above Company was held at the offices, Southampton, Mr. G. T. Harper occupying the chair.

The **Chairman**, in moving the adoption of the report and accounts (which were given in our last issue), said he thought the shareholders all appreciated the efforts of those who had brought the Company to its present position, and their belief that it would be a progressive concern was perfectly justified. He thought that by making the Company almost a dividend-paying concern in two years they were justifying the anticipations of Mr. Miller, and he trusted the Company would be made a good dividend-paying concern. In order to assist in accomplishing this the directors had decided to forego their fees, amounting to £400. It was most gratifying that instead of having a great balance against them of £754. 19s. 9d., it had been reduced by this means, and by the profit of £170. 1s. 11d. on the last year's working, to £184. 17s. 10d. Next year they would show a much better result, because the sales of electric current for the first two months of the year already showed an increase of 50 per cent. over the corresponding period of last year. If that progress continued, and the working expenses were kept down, he believed that at the end of the year they should not only be able to pay the debenture debt, but a dividend on the ordinary shares as well. The directors hoped that the Company would so recommend itself to the general public that they would be able to provide the capital needed for the works without going to the bank for it. During the year much could be done with increased capital, and the directors looked to the shareholders for that capital. He read the following statement showing that the Southampton Company compared very favourably with many electric light companies:

Name of company.	Units debited to customers.	Works cost in pence per unit sold.	Total cost in pence per unit sold.
Southampton (L)...	53,848	3·36	4·32
Chelsea (L)	402,848	2·79	4·32
Notting Hill (L) ...	107,580	3·75	5·29
Preston (L)	149,636	4·17	6·98
Preston House-to-House (H)...	358,506	4·06	5·15
*Oxford (H).....	103,859	3·50	5·71
Leeds (H)	130 068	3·20	4·87

* Eight months only.

It should be noted that the output of the Southampton Company was very considerably lower than that of any of the other companies he had named, and therefore the costs might have been expected to come out higher in proportion. For comparison, he would give the figures of two companies for 1892 whose output more nearly approached theirs—viz.:

Notting Hill... . ..	75,667	5·86	8·93
National	79,650	4·28	5·90

(L) Low tension (as in Southampton).
(H) High tension (as in Bournemouth).

The above companies, whose expenses were higher in proportion than theirs, were the only companies whose accounts were already published. This statement was signed by Mr. J. H. Lee. In conclusion, the Chairman said that the report was made out by a practical man—their engineer—who prepared monthly tables of costs, so that the directors knew what the Company was doing. He thought it was very satisfactory that their cost of production was, with two exceptions, the lowest on the list.

Mr. F. B. Turner seconded the adoption of the report.

Mr. J. Miller, J.P., in supporting the motion, said that the balance-sheet was pleasing, for it showed that if the public had come forward and subscribed for shares instead of their having to pay interest on money borrowed from the bank, they would have been able to pay a dividend of 3 per cent. He asked whether anything had been done with regard to obtaining a provisional order? He thought it was a great thing, as they wanted to establish their right to supply the current to Southampton.

The **Chairman** said that nothing could be done till July, when notice would be given and steps taken to get a provisional order.

The motion was then put to the meeting and was adopted.

The retiring directors, Messrs. J. F. Obree and G. J. Tilling, were re-elected, and Mr. C. Cox was reappointed auditor.

BUSINESS NOTES.

Western and Brazilian Telegraph Company.—The receipts for the past week were £3,113.

Eastern Telegraph Company.—The directors have declared a quarterly interim dividend of 2s. 6d. per share.

Great Northern Telegraph Company.—The directors have declared a dividend of 8·3 per cent. for the year 1893.

Liverpool Overhead Railway.—The traffic receipts of this railway for the week ending 8th inst. amounted to £691.

Burton.—The electric light is to be installed at the new municipal offices at an expenditure not exceeding £997. 13s.

Burton.—The number of customers for the electric light is increasing. Orders for nearly 900 lamps have been received.

Blackpool.—The electric light is now provided almost continuously, the exceptions being between the hours of 8 a.m. and 1 p.m. on week days, and 8 a.m. and 4 p.m. on Sundays.

Monmouth.—Messrs. Bramwell and Harris have agreed to advise the Town Council on their drainage and electric lighting schemes for a fee of 100 guineas and out-of-pocket expenses.

County of London Company.—The letters of allotment of the first issue of 19,900 ordinary shares in the County of London and Brush Provincial Electric Lighting Company are being posted.

Anglo-American Telegraph Company.—Quarterly interim dividends of 9s. per cent. on the ordinary stock and of 18s. per cent. on the preferred stock have been declared by the directors.

Storage Batteries.—Since the issue of the prospectus of the International Electric Storage Company, the German patent has been granted to Mr. Theryc, and advice of same has been received this week.

West India and Panama Telegraph Company.—The directors recommend a dividend of 6d. per share on the first and second preference and 9d. per share on the ordinary shares for the half-year ended December 31.

Folkestone.—The Folkestone Corporation last week, after four hours' sitting and many previous meetings, approved of the scheme for the installation of electric light, at a cost of £35,000, by a majority of nine to five votes.

Bakewell.—A letter has been received by the Local Board from the secretary to the telephone company promising that the state of the wires, etc., in Bakewell, which were pronounced to be dangerous, should receive immediate attention.

Ship-Lighting.—Messrs. David Dunlop and Co., of Port Glasgow, have launched the ss. "Maria Herrera," built to the order of a Havana firm. She has been fitted throughout with the electric light by Messrs. Claud Hamilton, Limited.

Indo-European Telegraph Company.—After placing £15,000 to reserve, the directors recommend a balance dividend of 17s. 6d. per share, and a bonus of 20s. per share, making a total distribution of 10 per cent. for the year ended December 31 last.

Stock Exchange Quotation.—An application has been made to the Stock Exchange Committee to appoint a special settling day in the shares of the Oriental Telephone and Electric Company, Limited, in lieu of those of the old company of the same name.

Electric Jib Wharf Crane.—As will be seen from our advertisement columns, Messrs. C. H. Glover and Co., Hatcham Saw Mills, Ormside-street, Old Kent-road, S.E., invite tenders for a travelling jib landing crane, and for a dynamo and lighting installation.

Birkenhead.—The special sub-committee of the Finance Committed on electric lighting have resolved to purchase the plot of freehold land, containing about 3,152½ square yards, situated in Bentinck-street, for £1,576. Their action has been approved by the Finance Committee.

Portsmouth.—The Electric Lighting Committee of the Town Council have submitted certificates from Messrs. Waller and Manville for the payment of £2,850 to the contractor of the electric light works for machinery, conduits, electrical plant, etc. These have been passed by the Council.

Shirley.—At a meeting of the Shirley and Freemantle Local Board of Health, it was agreed to ascertain on what terms the old washing factory at Mousehole could be obtained. The Chairman, in answer to questions, stated that if they took these premises they would have the right to use the water power.

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Weston-super-Mare.—The Electric Lighting Committee of the Town Commissioners reported on Wednesday that they had arranged for a canvass of the town to ascertain what public support was likely to be accorded to an electric lighting scheme.

City and South London Railway.—The receipts of the Company for the week ended April 8 were £852, against £842 for the same period last year, or an increase of £10. The total receipts for the first half-year of 1894 show an increase of £30 compared with those for the corresponding period of 1893.

Cheltenham.—The town clerk has laid before the Electric Lighting Committee of the Town Council the sanction of the Local Government Board to a loan of £1,600 for the purposes of electric lighting, repayable in 25 years, and to the use of part of the site of the destructor for the electric lighting station. The report has been adopted.

Bournemouth.—The Town Council have passed the following plans submitted by the electric supply company: fuse-boxes, Portarlington and Marlborough roads, extension of transformer pit in the Square and on Richmond-hill, the two latter being passed "subject to the covers being hinged to the satisfaction of the surveyor."

Buckingham.—At a meeting of the Town Council a tender has been received from the gas company for lighting the public lamps. It was stated that the Council having accepted the tender of Messrs. Parr and Gillies to light 10 of the public lamps with the electric light, they could not accept the tender of the gas company to light those lamps.

Scarborough.—The Scarborough Bridge Cliff Company have decided to introduce the electric light into the theatre. The cost of the installation is estimated at £300. The current will be obtained from the local supply company. The introduction of the light into other buildings and grounds of the company has been left for future consideration.

Tenders for Emsworth (Hants).—Tenders are invited by 26th inst. for the lighting of the public lamps for one year, commencing July 22, 1894, to July 21, 1895, for the Inspectors of Lighting. Tenders will be considered at the meeting of the inspectors to be held on May 7, and should be delivered to Mr. J. W. Loader Cooper, clerk, Queen-street, Emsworth.

Wisbech.—The Town Council have ordered that tenders for public lighting shall be advertised for. At a meeting of the Council Mr. Stanley asked if it was the intention of the Council to advertise for electric lighting, and on his proposition it was decided that the advertisements should read, "lighting by gas, electricity, or otherwise, for one, two, or three years."

Tenders for Brighton.—The Town Council, as notified in our advertisement columns, are asking for tenders for the supply and erection of Willans engines, continuous-current dynamos, pipe work, spare armatures, etc. Specifications can be had on application at the town clerk's office at the Town Hall, Brighton. Sealed tenders to be sent in by the 30th inst.

Tenders for Telephone.—As stated in our last issue, the Committee of Visitors of the North Wales Counties Lunatic Asylum invite tenders for the construction and maintenance for a period of five years of a telephone between the asylum and Glanywern Hall, a distance of about three miles. Further particulars may be obtained from Mr. Wm. Barker, clerk to the Visitors, the Asylum, Denbigh.

Keighley.—Colonel Hasted, R.E., of the Local Government Board, has held an enquiry into an application of the Town Council to borrow £41,000 for gasworks purposes. The Town Clerk stated that in view of the determination of the Corporation to apply in the coming session for powers to supply the electric light, the profits in the future could not be expected to be as large as formerly.

New Firm.—We are informed that Mr. Cathcart, late partner in the firm of Messrs. Cathcart, Peto, and Radford, has commenced business under the title of Messrs. C. H. Cathcart and Co., and has opened offices and works at 4, Dorset-buildings, Salisbury-square, Fleet-street, E.C., to which address all business communications should in future be sent. The telegraphic address is "Coefficient, London."

Aberdeen.—The Road Sub-Committee of the Aberdeen District Road Committee have reported that the Northern Electric Supply Company had asked to be allowed to lay mains across the Deeside-road at Cults at two points, that the sub-committee had resolved to recommend that the application be agreed to under certain conditions, and that the rent be £1 per annum. The committee have adopted the recommendation.

Lighting of Derby House.—Messrs. Drake and Gorham have been entrusted with the lighting of Derby House, where extensive alterations and additions are being made. The few lights which already exist in one or two rooms will be taken away entirely, and the arrangement throughout will be in accordance with their usual system in work of this class—viz., shaded lighting. The number of lights being installed is about 400.

Taunton.—The Town Council have presented Mr. J. A. Robinson with a silver-plated liqueur stand, in recognition of the valuable assistance and advice he had rendered them in connection with the electric light works. Mr. Robinson has for some years been locomotive superindent of the Great Western Railway at Taunton, and he has recently been promoted to a higher position in the locomotive department, which has necessitated his removal to Newton Abbot.

New Installations.—Messrs. Rashleigh Phipps and Co., of 102, Oxford-street, have just received instructions for the electric lighting of Mr. George Grossmith's house in Dorset-square, which has to be completed within a fortnight, to be ready for his return from America. This firm is also engaged upon the electric lighting of the Earl of Fingall's house in South Audley-street, as well as a complete plant at Mr. Netlam Rattray's mansion at Bear Hill, Twyford.

Portobello.—At a meeting a few days ago of the Town Council, the report by the special committee appointed in November to enquire into the question of public lighting was submitted. The report said that the second part of the remit made to the committee was to enquire into all the available sources of lighting supply, and in this direction the committee enquired as to the advisability of introducing electricity, but found that at present it would be too expensive a system to recommend.

Radcliffe.—The Electric Lighting Committee of the Radcliffe Local Board have recommended the approval of the high-pressure alternating system for the lighting of the district. At a meeting of the Board, the Chairman said that in all probability at the next meeting there would be a resolution submitted on the basis of the two reports by the experts who had been engaged. The committee would also be prepared to suggest that the Board apply for an order for powers to carry out a scheme of electric lighting.

Exhibition of Electric Heating and Cooking Apparatus.—An exhibition of electric heating and cooking apparatus is now being made by Messrs. Crompton and Co. at the showroom of the London Electric Supply Corporation, Belgrave-mansions, Ebury-street, S.W. The first demonstration was given yesterday (Thursday), between 3.30 and 5 p.m., and further displays will be given every Thursday until further notice. Apart from this, the apparatus is always on view between 11.30 a.m. and 7 p.m.

International Electric Storage, Limited.—This Company has been registered with a capital of £200,000 in £5 shares. The object is to acquire all or any part of the shares, works, property, and liabilities of the Universal Electric Lighting Company, Limited; to acquire all or any of the letters patent of Messrs. Theryc and Oblasser for electric accumulators granted to them in the United Kingdom and elsewhere, and to generate and distribute electricity. The first signatories are: S. F. Page, J. L. Higgs, J. G. B. Elliott, J. H. Mace, B. H. Van Tromp, Colonel E. Villiers, and A Schanschieff.

South Staffordshire Tramways Company.—On Wednesday, the petition presented by shareholders for the winding up of this Company again come before the Courts. Objection was taken that a company which had been incorporated by Act of Parliament could not be wound up on a petition presented by a shareholder. After some argument, Mr. Justice Vaughan Williams overruled the objection, and said he thought there might be some benefit to the shareholders in winding up, because he thought there would be a surplus to be divided. The persons who charged fraud, however, must furnish further evidence. The petition was accordingly adjourned for further evidence.

Tenders for Working the Leeds Tramways.—The Corporation having become owners of the tramways, invite tenders, at a rental per mile single line of track, for the working of the lines, for the alternative periods of seven, fourteen, or twenty-one years. There are about 27¾ miles of tramways calculated as single track. Those tendering must state what motive power they propose using—that is to say, whether horse, steam, cable, electric, or what other power—and whether over specified parts or the whole of the system. Forms of tender and conditions of letting may be obtained on application to the town clerk. Tenders must be addressed to the chairman of the Highways Committee, Town Hall, Leeds, by May 5.

Bootle.—At a meeting of the Town Council held on Wednesday, Mr. Morton moved the confirmation of the proceedings of a sub-committee as to electric lighting which recommended that the system of lighting by electricity all the Corporation buildings, including the Town Hall and offices, library and museum, police court and station, and baths, be adopted. The sub-committee also recommended that tenders for the execution of the necessary work be obtained and submitted to the next meeting of the Council, and that the Finance Committee be directed to apply for the sanction of the Local Government Board to a loan not exceeding £3,600 with which to carry out the works. The motion was adopted.

Great Missenden (Bucks.).—An exhibition of electrical cooking and heating arranged by Messrs. Habgood and Smith, electrical engineers, 49, Queen Victoria-street, E.C., and Great Missenden, was held at this village on 4th and 5th inst. The apparatus, which comprised ovens, frying-pans, kettle, flatirons, etc., was lent by Messrs. Crompton and Co., Limited. Mr. Habgood gave a short introductory lecture on the application of electricity to heating purposes. During each evening, samples of the electric cooking were given to everyone present. Music was rendered at intervals, and altogether very pleasant evenings were spent The lighting of the village is still progressing favourably, and is being well taken up by private consumers.

Watford.—Mr. Rogers has written to the Local Board in reference to electric lighting, stating that it was now nearly 18 months since there was formed in Watford an electric lighting company with the Earl of Essex as president. On receiving a communication from the Board, the company decided not to proceed further with the scheme, as it was understood the Board would themselves apply for a provisional order. He asked whether it was still the intention of the Board to do so. At a meeting of the Board the Chairman said he thought it was still the Board's intention to keep the matter in their own hands; but it was suggested by Mr. Andrews that the condition of the Board's finances did not at present justify the carrying out of a scheme.

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Hotel-Lighting.—On Thursday last week, Mr. Edwin Stephens, proprietor of the New Drayton Court Hotel, Ealing Dean, held a reception to celebrate the opening of that hotel. The electric lighting was universally pronounced as being perfect. The plant consists of one of Mr. Ronald Scott's new type of compound-wound dynamos, driven by a high-speed Crossley gas-engine, no accumulators being used. The dynamo is provided with a heavy flywheel, and Mr. Ronald Scott was congratulated on all sides on the perfect steadiness of the lights. It was shown that, whether the plant was doing one-tenth or full load, the perfect steadiness was maintained throughout. The number of lamps in use is about 100.

Dublin.—The National Telephone last year absorbed the Irish Company, and complaints have since been made in Dublin as to the company's attitude to subscribers there. Concessions have, however, now been made. In the important question of the rental, the £12 rate for exchange wires has been reduced as from January 1 last to £10, and the condition as to the five years' term withdrawn, and subscribers are allowed to remain on on the previously existing contracts. As to the future management of the Dublin concern it practically remains unchanged, as the Board of the Irish Company has been continued as a local Board for the purpose of advising the Board of the National Company.

Chadwick v. Woking Electric Company.—A motion for judgment in the debenture-holder's action, Chadwick *v.* the Woking Electric Supply Company, Limited, was made last week before Mr. Justice Stirling. The company had issued 60 debentures of £50 each and six of £500 each, and there had been default in payment of the interest. The principal thereupon became due and payable. Counsel explained that the receiver appointed in the action had entered into a provisional contract with certain persons for the sale of the whole business as a going concern. Under these circumstances his Lordship made an order for the usual account of the amounts due on the debentures, and an enquiry as to priority, with liberty to apply in chambers as to the realisation of the property.

Dover.—At a meeting of the Dover Town Council last week, a further letter was read from the Board of Trade with reference to the electric lighting regulations. The surveyor reported that he had agreed to allow the electric light company to put down their mains, and it had been thought advisable to put them under the footways instead of the roads, so that when connections were made with houses the paths need not be all broken up. The men in the employ of the Council were digging the trenches and repairing the paths in accordance with the agreements with the company, the latter to pay for the labour, etc. The positions of the electric light lamps were also reported upon. The town clerk announced that the £200 deposit by the electric light company to cover the cost of the works had been paid.

The Alhambra Theatre.—The Theatre and Music Halls Committee of the London County Council report that they have received a plan, submitted by Mr. P. W. D'Alton, engineer to the London Electric Supply Corporation, Limited, showing the formation of a converter-chamber in the basement of the Alhambra Palace for the purpose of enclosing transformers supplying electric light to the stage. They recommend that the plan be approved on the conditions that the walls of the chamber be not less than 9in. thick; that a self-closing wrought-iron door, fitted in a wrought-iron frame with a 3in. lap, built into the wall, be provided to the chamber in lieu of the present one, which is too slight; and that the ventilation and lighting of the room be carried out to the satisfaction of the engineer of the Council.

Notices Under Electric Lighting Acts.—The Highways Committee of the London County Council have considered four notices from the House-to-House Electric Light Supply Company of intention to lay mains on the west side of Gilston-road, on the north side of Lexham-gardens, along one side and across Wright's-lane and in Cheniston-gardens, and in a part of Gloucester-road. Both high and low tension mains are proposed to be used. The committee recommended that the sanction of the Council be given to the works referred to in these notices. They have also considered a notice from the Charing Cross and Strand Electricity Supply Corporation of intention to lay mains across and along a part of the east side of Adelaide-street. The committee recommended that sanction be given to the works.

Indo-European Telegraph Company.—The directors state that the revenue from all sources for 1893 amounted to £122,860, as compared with £117,479 for 1892, an increase of £5,381. The expenses were £64,960, as against £62,149, an increase of £2,811. Deducting these expenses, taking credit for £7,558 brought over, and debiting income tax, there remains a sum of £63,952. From this £15,000 has been placed to reserve, and that sum, together with £10,625 amount of interim dividend, have to be deducted, leaving a balance of £38,327. The directors now propose to declare a dividend for the last six months of 17s. 6d. per share, making, with the dividend already paid, 6 per cent., and a bonus of 20s. per share, both free of income tax—in all, 10 per cent. for the year, carrying forward £6,452 to the credit of 1894.

Ayr.—The burgh surveyor, Mr. John Eaglesham, has presented a report and plan to the Town Council as to the proposed installation of the electric light in the burgh. He estimated the total number of lights at 4,000 for private consumption, with 15 2,000-c.p. street lights to replace 95 gas lamps. It was estimated that, as compared with gas, the price of which in Ayr is 4s. 2d. per 1,000ft., the expenditure for a year's burning of about 500 hours would be, for eight-candle lights, gas 6s. 3d., electric light 6s. 10d.; for 16-candle lights, gas 8s. 4d., electric light 12s. 10d. The estimated cost of laying down steam plant for such an installation would be £11,000. The annual outlay, including capital outlay, was estimated at £1,641, and the income for 3,000 lights, in addition to street lights, £1,650. It was agreed to ask Mr. Robert Hammond to visit and survey the burgh with a view to the introduction of the electric light.

Presentation at Brighton.—A complimentary dinner to Mr. G. J. Philpott, chief engineer of the Brighton and Hove Electric Light Company, was held at the Imperial Hotel on Saturday evening. After the loyal toasts the chairman (Mr. G. Spencer Hawes), in presenting to Mr. Philpott a handsome gold watch and chain, referred to the long time that Mr. Philpott had been connected with the company and to the respect in which he was held. The chairman then formally presented the watch to Mr. Philpott, adding that it was accompanied by a feeling of goodwill as sterling in its standard of sincerity and heartiness as the metal of which the souvenir was composed. Mr. Philpott, in responding, said that he was quite unable to thank them sufficiently for the honour that had been done him, but he could assure them that that splendid present would always be an interesting memento of his connection with the Brighton and Hove Company.

The Bury (Lancs.) Tenders.—The tender of Mr. S. H. Heywood, of Manchester, has been accepted for the supply of electric light fittings, including switchboards, lamps, wiring, etc., for lighting the technical school now in course of construction in Broad-street, for the Technical School Committee of the Corporation. The following also tendered: Dugdill and Co., Failsworth; Moorhouse and Son, Burnley; E. Dewhurst, Preston; Northern Counties Company, Manchester; J. H. Hindle, Bury; Doninson, Parmiter, and Co., Manchester; Corlett Engineering Company, Wigan; Barnett and Co., Newcastle; Laing, Wharton, and Co., London; Manchester Edison Company, Manchester; Bury and Pope, Burnley; J. Faulkner, Manchester; T. Barton, Blackburn; Drake and Gorham, Manchester; Lowcock, Hill, and Co., Manchester; Graham and Biddle, London; Strode and Co., London; Andrews and Co, London; H. A. Clegg and Co., Manchester.

Lighting of Omnibuses and Tramcars.—As mentioned in previous issues, for some five weeks past a car has been run by the London Street Tramways Company from Westminster Bridge to Streatham which has been fitted by Mr. Froggatt with two 5-c p. lamps inside and two lamps of the same power outside. Inside the car it is possible to read the smallest print with comfort. Outside two lamps are placed, one at each end of the car, and it is also possible to read small print when seated in the middle of the car. The lamps are raised on iron supports, and are visible at a distance. It is proposed to have a different coloured lens for each lamp, so that a passenger can tell at a glance the destination of the car. The current is supplied by batteries carried under the seat of the car. The system has given satisfaction to the company, and it is said that they are about to fit the whole of their cars with it. It has also been adopted by the Atlas and Waterloo Omnibus Association and by the Star Omnibus Company.

Eastern Extension Telegraph Company.—The report of the Eastern Extension, Australasia, and China Telegraph Company for the half-year ended December 31 states that the gross receipts, including Government subsidies, amounted to £251,698, against £247,767 for the corresponding period of 1892. The working and other expenses absorbed £76,575, against £91,769, leaving a balance of £175,123. From this is deducted £4,015 for income tax, and £31,895 for interest on debentures, debenture stock, and contribution to sinking fund, leaving as the net profit £139,213, which, with £81,117 brought forward from the previous six months, shows an available balance of £220,330. One quarterly interim dividend of 1¼ per cent. has been paid for the half-year, and it is now proposed to distribute another of like amount, making, with the interim dividends paid for the first six months, a total dividend of 5 per cent. It is also proposed to pay a bonus of 4s. per share, or 2 per cent., making a total distribution of 7 per cent. for the year. The balance of £107,830 has been carried to the general reserve fund, which, after being credited with interest received on investments, now stands at £633,686.

Isle of Man Tramways and Electric Power.—The Isle of Man Tramways and Electric Power Company, Limited, has been formed with a nominal capital of £150,000 for the purpose of purchasing and working under one management the Isle of Man Tramways and the Douglas Bay Estate, formerly the Howstrake, Tramway, with the authorised extensions either prospective or in course of construction. The whole of the undertakings—permanent way, land, buildings, and other property—is to be handed over as a going concern fully equipped and in working order for £175,000, the vendors reserving the right to subscribe for one-third of the capital. The prospectus states that the Isle of Man Tramways is one of the best paying in the kingdom, the net profits in 1891 being £2,820, in 1892 £2,907, and in 1893 £3,784. An annual gross revenue of £28,250 is estimated, of which, after allowing for working expenses and the interest on debentures and preference shares, £9,025 is expected to be available for dividend on ordinary shares and the formation of reserve. There are now offered for subscription 125 000 £1 shares, of which £50,000 are 6 per cent. preference and 75,000 ordinary; £50,000 debentures in bonds of £20, or multiples of £20, are also to be issued. The list closes on or before to-morrow (Saturday).

Bedford.—In our last issue reference was made to the deputations who had waited upon the Board of Trade with regard to the question as to who should supply the electric light in the town, and to the decision of the Board of Trade in the matter. It will be remembered that it was left to the Corporation to decide whether they would or would not carry out their electric lighting powers. At a meeting of the Corporation on Monday, the question was discussed at considerable length. The Mayor moved that the

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authority carry out the supply in the compulsory area set out in proposed provisional order of the Bedford Electric Light Company, Limited, before January 1, 1895. The motion was seconded, but an amendment was proposed by Mr. Blaydes that the authority before committing the town to any further expenditure in connection with the installation of the electric light order a poll to be taken to ascertain whether they wish the authority or a company to undertake the electric lighting of the town. This was seconded, and after further discussion, the Mayor put the amendment, which received 11 votes as against 13; it was therefore lost. On the substantive motion being put, it was carried by 14 votes to 11. A motion was then carried empowering the Electric Lighting Committee to carry into effect the foregoing motion, including the employment of an engineer.

Bristol.—In our last issue we mentioned that the Bristol Sanitary Committee were to have before them at a meeting their half-yearly estimates, including that for electric lighting. The estimate for the half year, March to September, amounted to £4,750, as compared with £2,663 in the corresponding half-year of 1893. Mr. George Pearson, the vice-chairman of the committee, pointed out, in connection with the accounts, that the saving in gas for the year would be about £1,700. The Electric Light Committee, however, had to spend much more than that to give the city the light it was receiving. Their estimate was that it would cost £2,400 for the electric light they had now in the streets, and for which they formerly paid in respect of gas about £1,700. That enabled the Electric Lighting Committee to reduce their claim by about £800, the amount of the estimated value of the electric light for the coming half-year, and by the repayment of £1,600, an instalment of the loan, which they should make during the coming half-year. That meant that £2,400 of the £4,750 asked for under the head of electric light would not be lost to the city, so that the actual cost of the electric light for the half-year was £2,350. Opposition to the electric tramway to Kingswood still continues. The Chairman of St. George's Local Board has informed the Board that he has interviewed several residents at West-street, who objected to the proposed electric tramway to Kingswood on the ground that portions of that thoroughfare were not wide enough to allow of the extra traffic which the scheme, if carried out, would entail. Although he had not been able to convince these persons of the unsoundness of their arguments, he felt that their opposition would not upset the scheme, though some little delay might be caused.

Lighting at Accrington.—The minutes of the Legal and Parliamentary Committee, presented at a meeting of the Town Council last week, contained a recommendation to the Council to put down an installation of electric light to supply not less than 2,000 16-c.p. incandescent lamps, with provision for extension. On the minutes coming up for confirmation, Mr. Duckworth asked if nothing more could be done to influence tradesmen in regard to adopting the electric light. Mr. William Robinson moved an amendment that the minutes be referred back. He objected to the light from a financial point of view. If they were bound to adopt the light in order to keep out private companies, he thought they might adopt some cheaper scheme. Mr. Grace seconded the amendment. Seeing that electric light was likely to cost something like £10,000, he was not in favour of proceeding with it. They had had a deputation at Morecambe, but he had not heard that they were making 1 per cent. at Morecambe, and he would not go in for a business that was not paying. If they could have produced electricity as cheap as they talked of, they would not have gone in for the gasworks. He did not see the sense of opposing themselves by spending money they knew they could not have interest on. Mr. Eli Higham, while of opinion that the light would not pay for the first two or three years, thought it would eventually. There were many enterprising electricians who would be willing to come into the town and light it. They had got the necessary parliamentary powers, but the time had gone, and unless they were willing to take some steps they could not both hold their hands themselves and prevent other people from coming in. They were not in favour of another monopoly being formed. He was of opinion that when the shopkeepers saw the light they would quickly adopt it; that had been the case in Burnley. He only asked either that the Council should decide to go on with it or decide that some other party should come in. The minutes were eventually referred back to the committee.

PROVISIONAL PATENTS, 1894.

APRIL 2.

6512. **Improvements in dynamo-electric generators and motors and allied machines.** Frederick Henry Royce, 53, Arcade-chambers, St. Mary's-gate, Manchester.

6528. **Improvements in dynamo-electric generators and motors and allied machines.** Frederick Henry Royce, 53, Arcade-chambers, St. Mary's-gate, Manchester.

6554. **Improvements in or additions to metallic tubular telegraph poles and metallic tubular poles for other purposes.** Bullers, Limited, and Edward John Chambers, 7, Staple-inn, London.

APRIL 3.

6606. **Systems for controlling electric lights.** Charles Arthur Allison, 52, Chancery-lane, London. (The Electrical Speciality Company, United States.) (Complete specification.)

6623. **Improvements in electric lighting apparatus.** Percy Ruskin Allen, 46, Lincoln's-inn-fields, London.

6649. **A new or improved mechanical indicator for electric and other bells.** Abraham Kershaw, 33, Chancery-lane, London.

6661. **Improvements in electric switches.** Thomas Joseph Rorke, 45, Southampton-buildings, Chancery-lane, London.

APRIL 4.

6721. **Improvements in apparatus for signalling between police stations and district call-boxes.** The National Telephone Company, Limited, and Charles Eggar, 62, St. Vincent-street, Glasgow.

6732. **Improvements in apparatus or machinery for making draught extinguisher strips for covering electric cable wires with ribbon and for like uses.** George Clapham, 6, Lord-street, Liverpool.

6742. **An electrically-operated electric switch.** Siemens Bros. and Co., Limited, and George Sylvester Grimston, 28, Southampton-buildings, Chancery-lane, London. (Complete specification.)

APRIL 5.

6776. **Improvements in continuous recording instruments.** Herbert Nalder, Charles William Scott Crawley, and Alfred Soames, 16, Red Lion-street, Clerkenwell, London.

APRIL 6.

6850. **Electric lamp protector.** William Thomas Ungley, jun., 117, St. John-street-road, Clerkenwell, London.

6888. **Improvements in telegraphic and telephonic apparatus.** John Imray, 28, Southampton-buildings, Chancery-lane, London. (La Société Anonyme pour la Transmission de la Force par L'Electricité, France.)

6912. **Improvements in and relating to moulds for casting grids for the active material of electrical accumulators.** The firm of Kölner Accumulatoren-Werke Gottfried Hagen and Carl Beyer, 45, Southampton-buildings, Chancery-lane, London.

6917. **Improvements in apparatus for electrolytical purposes.** Herbert Guthrie, 46, Lincoln's-inn-fields, London.

APRIL 7.

6942. **Improvements in "cords" and plugs for telephonic switchboard circuits.** Daniel Sinclair, 62, St. Vincent-street, Glasgow.

6947. **Improvements in plates or electrodes for accumulators.** Robert J. Gülcher, 6, Lord-street, Liverpool. (Complete specification.)

6975. **Improvements relating to the manufacture of plates or electrodes for electric accumulators or secondary batteries, and to machinery or apparatus therefor.** Arthur James Smith and Henry John Wright, 11, Southampton-buildings, Chancery-lane, London.

SPECIFICATIONS PUBLISHED.

1884.

10215. **Electrical tramcars, etc.** Reckenzaun. (Second edition.)

1892.

13894. **Submarine telegraph cables.** Preece. (Second edition.)

23101. **Galvanic batteries.** C. A. J. H. and H. E. R. Shroeder.

1893.

6205. **Distributing electricity for lighting, etc.** Wood.

9380. **Breaking electric circuit.** Haddan. (Reisinger.)

9557. **Dynamo-electric machines.** Prentice.

10942 **Primary voltaic batteries.** Walker and Wilkins.

24517. **Advertising reflector for electric light globes.** Mockler.

24911. **Electric cables.** Dewees.

1894.

3020. **Induction electrical machines.** Tudsbury.

3384. **Electric lamps.** Turnbull.

COMPANIES' STOCK AND SHARE LIST.

Name	Paid.	Price Wednesday
Brush Co.	—	3¼
— Pref.	—	2¼
Charing Cross and Strand	—	5
City of London	—	12¼
— Pref.	—	13¼
Electric Construction	—	½
House-to-House	5	1½
India Rubber, Gutta Percha & Telegraph Co.	10	23½
Liverpool Electric Supply	5	6⅝
	4½	5½
London Electric Supply	5	1
Metropolitan Electric Supply	—	8⅜
National Telephone	5	4⅝
St. James', Pref.	—	8¼
Swan United	3½	3½
Westminster Electric	—	6

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NOTES.

Nantes.—An extension of the public arc lighting is to be made by the Municipality.

Saint-Leonard.—This district in the Haute-Vienne is to be lighted electrically on July 14.

Marseilles.—The Municipality have approved of the extension of the electric light in the town.

Hastings.—The Palace Hotel is now being lighted by electricity, and it will reopen to-morrow (Saturday).

Saint-Clers.—M. Albert Lafforgue is about to establish a central electric and power station at Saint-Clers, Gers.

Chlorate of Potassium in France.—Works for the electrolytic production of chlorate of potassium are being erected in Savoy.

Salon.—The Municipality of Salon, Bouches-du-Rhône, have given the concession for the electric lighting of the town to M. Grammont.

Madras.—The severe heat which has prevailed has retarded the work of constructing the permanent way of the Madras electric tramway.

Lecture.—Mr. T. Scott Anderson gave his second lecture on electrical engineering at the Central Higher School, Sheffield, on Monday.

Buckingham.—The Town Council have asked the electric light company to tender for the remaining public lighting with incandescent or arc lamps.

Bombay.—Messrs. J. Fleming and Co., of Bombay, are putting up an electric light installation in the Arthur Crawford Markets for the Bombay Municipality.

Budapest.—The Hungarian Ministry of Commerce has approved of the bulk of the project for the establishment of an electric railway on the quays of Budapest.

Institution of Mechanical Engineers.—The anniversary dinner was held on Wednesday evening at the Freemasons' Tavern, Prof. A. B. W. Kennedy presiding.

Society of Arts.—On Wednesday next, at 8 p.m., a paper on "Some Recent Developments of Photographic Chemistry," by Mr. Chapman Jones, F.C.S., will be read.

Charing Cross-Hampstead Railway.—The South-Eastern Railway Company have withdrawn their petition against the Charing Cross, Euston, and Hampstead Railway Bill.

Strassburg.—Tenders are to be invited by the municipality for a central electric light station for this city. The plans of Herr Oscar von Miller will have to be followed.

Manchester.—The members of the Gas Committee of the Corporation met last week at the electric light station to witness the unveiling of a tablet recording the starting of the works.

That New Reservoir. — "Is not a dynamo a reservoir?" asked a reporter the other day. "Yes," was the reply; "it's a kind of boiling tank to keep the electricity hot."

The Guildhall.—The Court of Common Council decided last week to extend the electric light installation at the Guildhall to the art gallery at an estimated cost of £290, inclusive of fittings.

Coatbridge Electricity Works.—We have received a copy of a pamphlet describing these works and the opening ceremony on the 31st ult. The works were described in our issue of the 6th inst.

Electricity in the Navy.—It is reported that electricity is to be increasingly utilised as a motive power in the British Navy, and that every gun on future warships will be equipped with electrical appliances.

The Institution.—A paper on "The Cost of Electrical Energy," by Mr. R. E. B. Crompton, M.I.C.E., vice-president, will be read at a meeting of the Institution of Electrical Engineers on Thursday next, the 26th inst.

Orleansville. — M. Gastambide, who has been the successful tenderer for the lighting of this town, is busily engaged in the installation of the station. The generating plant will comprise two 50-kilowatt Patin alternators.

Proposed New French Cable.—The Minister of the Colonies is about to bring in a Bill authorising the laying of a supplementary cable between Obock and Djiboutil, two French colonial stations on the Red Sea.

Electric Haulage Plant.—Some discussion took place last week at a meeting of the Mining Institute of Scotland, on a paper read at a previous meeting by Mr. Forgie on "Electric Haulage Plant at Drumbreck Colliery."

Budget Item.—We pay taxes for various things, but not for wind. The directors of the Rollason Motor Company hope that the Chancellor of the Exchequer will not impose a tax on their using wind for driving the Rollason motors.

Plymouth.—The Town Council will oppose the local gas company's Bill now before Parliament, in which powers are asked to supply the electric light, as the Council are obtaining a provisional order for the same purpose.

Serajewo.—The municipal authorities have decided to introduce the electric light, and also to build an electric tramway. They have arranged with the Hungarian Mortgage Bank, of Budapest, for a loan of the money necessary.

Provisional Orders.—Permission has been given to bring a Bill in the House of Commons to confirm certain provisional orders made by the Board of Trade under the Electric Lighting Acts, 1882 and 1888, relating to Chesterfield and Buxton.

Brechin.—The Municipality have decided, in connection with a motion to apply to the Board of Trade for a provisional order to supply electricity, to postpone the matter for a month, for the purpose of obtaining further information on the matter.

Sheffield.—A meeting of the directors of the Sheffield Electric Light and Power Company was held on Wednesday, when the applications for the new shares were considered and allotments made. The capital required has been fully subscribed.

King's College, London.—The thirty-fourth annual dinner of the old students will take place at the Holborn Restaurant on Wednesday, May 30. Further information may be obtained from Mr. Wm. Vincent, honorary secretary of the committee.

The Joule Fund.—The sum of £258, representing the amount handed to the Manchester Literary and Philosophical Society as the surplus of the Joule Memorial Fund, has been invested as a nucleus of a Joule Fund to be administered by the society.

North of England Institute of Mechanical Engineers.—A meeting of the members of this institute was held at Newcastle on Saturday afternoon, when Prof. H. Stroud, M.A., D.Sc., read a paper on "Magnetic Delineation and its Variations."

Electric Lighting of Derry.—The Local Government Board has agreed to grant to the Derry Corporation a

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further loan of £2,870 in excess of the original loan, so as to enable the Corporation to complete the original scheme for the erection of 160 arc lamps.

Cardiff.—The Lighting and Electrical Committee of the Cardiff Town Council on Tuesday decided to carry out the recommendation of the Watch Committee, and fix distinctive lights upon certain lamps in the town, which will indicate the position of the fire-alarm boxes.

Crecy.—A thirty years' concession has been granted to M. O. Patin for the electric lighting of Crecy-en-Brie, Seine-et-Marne. A hydraulic motor will drive a 25-kilowatt Patin alternator, giving current at 2,000 volts, which will be reduced by transformers at the places where it is used.

Carbon Plates and Batteries.—The Atlas Carbon Manufacturing Company, Limited, of Ewer-street, Southwark-street, S.E., have sent us a copy of their price-list of carbon plates and rods, and of Leclanché and other batteries. The company supply carbons and batteries of all kinds.

Personal.—We understand that Mr. R. W. Weekes has signed an agreement with Messrs. Johnson and Phillips as head designer. Dr. Tilden, F.R.S., Professor of Chemistry at Mason College, has been appointed Professor of Chemistry at the Royal College of Science, South Kensington.

A Progressive Supply Company.—The number of 8-c.p. lamps supplied by the Metropolitan Electric Supply Company increased from 124,000 in 1892, to 166,000 in 1893. The present number of lamps connected is 175,000, and further applications continue to be received in satisfactory numbers.

Electricity in Agricultural Operations.—The United States Senate Committee on Agriculture has made a favourable report upon a Bill to establish an experimental electrical station for the purpose of determining whether electricity can be profitably applied as a motive power in the propulsion of farm machinery.

Caen.—The Chamber of Commerce has decided to light the port and water approaches by means of the electric light, by which navigation can be carried on at any hour. The report, containing all the particulars necessary for carrying out the project, will be placed at the disposal of firms desirous of tendering for this important affair.

Prof. Forbes Forgot This.—Two men—impressed with the mighty avalanche of waters—were gazing upon the Falls of Niagara. Says one: "Ah! there's a tremendous waste of water!" The other replied: "So you feel practically interested in it; are you an electrical engineer?" "Oh, no! only a dairy farmer," was the answer.

Long-Distance Telephony.—We recently referred to the opening of telephonic communication between Canterbury and London. Conversation has since then been carried on between the district office at Canterbury and persons at Newcastle-on-Tyne, Manchester, Birmingham, and elsewhere. These lines are not, however, yet open for public use.

Electric Lighting Provisional Orders.—The Board of Trade have made orders under the Electric Lighting Acts relating to Barrow-in-Furness, Buxton, Chipping Wycombe, Chesterfield, St. Helens, West Hartlepool, Grimsby, Harrow, Leyton, Monmouth, Peterborough, and St. Austell, and Bills to confirm them have been just laid before the House of Commons.

Municipalisation of Tramways.—It is stated that the London Street Tramways Company will carry to the House of Lords the appeal against the decision of the arbitrator in the case at issue between them and the London County Council, as to the acquisition by the County Council of certain of the company's lines, which was upheld on Thursday of last week in the Court of Appeal.

Standard Screw Threads.—The German Union of Electricians at their first general meeting, held at Cologne last year, appointed a committee, under the chairmanship of Prof. Hagen, for the introduction of a standard screw thread. The committee have just held a sitting, and the result of their labours will be presented at the general meeting of the union to be held in Leipzig in the middle of June.

Thomas Parker, Limited.—Mr. T. Parker, we understand, has not severed his connection with electrical work, but has become the head of another manufacturing company, the title of which is "Thomas Parker, Limited." The capital for this Company has, we hear, been all privately subscribed, so that no prospectus will be issued to the public. The works of Thomas Parker, Limited, are at Wolverhampton.

Scientific Instruments.—We have received from Messrs. John Davis and Son, of All Saints' Works, Derby, and 118, Newgate-street, E.C., a catalogue of various scientific instruments made by them. These include the Henderson patent traverser, and the Ogle protractor, theodolites, miners' dials, anemometers, miners' safety lamps, engine counters, speed recorders, pressure and vacuum gauges, planimeters, and drawing instruments.

The Singapore and Hong-Kong Cable.—The Eastern Extension, Australasia, and China Telegraph Company, Limited, have completed the laying of the first section of their alternative cable between Singapore and Hong-Kong—namely, between Singapore and Labuan. In addition to affording direct telegraphic communication with Labuan, this line practically brings British North Borneo into telegraphic communication with the rest of the world.

Rouen.—Eleven tenders have been sent in for the electric lighting of the port of Rouen. The lowest was by the Société Alsacienne, which amounted to 54,835f., or, say, £2,193, and the highest was by the Etablissements Cail, which amounted to 125,000f., or, say, £5,000. Application has been made by a company formed by M. Pitot, a local banker, for a concession for a system of electric tramways. It is proposed to use accumulator cars.

The Future of Gas.—A paper was read last week before the Society of Arts, by Prof. Vivian B. Lewes, on "London Coal-Gas and its Enrichment." At the close of the discussion, Mr. J. Norris Pimm, who presided, said he believed that in the future gas would be used more for motive power and heating purposes than for lighting. He had an electric light installation in his own house, but his gas bill was more than it used to be, gas being used as the means of producing electricity.

The Late Henry Giffard.—In his will the late M. Henry Giffard made the State his residuary legatee, with instructions to utilise what remained of his fortune, after payment of special legacies, for useful foundations, prizes, etc. A sum of 100,000f. has now been given from this bequest to the Société Internationale des Electriciens, to be employed in the construction and management of a special pavilion at the central laboratory, under the condition that it bears the name of Henry Giffard upon it.

Stirling.—The subject of the electric lighting of this town, to which we referred in our last issue, continues to receive the attention of the Municipality. At the last meeting of the Town Council letters were read from two

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electric lighting companies with regard to supplying the town. It was agreed to acknowledge receipt of the communications, and remit to the Electric Light Committee to obtain all necessary information in view of the Council applying for a provisional order in November.

Killarney.—A curious state of affairs exists here in connection with the lighting of the streets. A majority of the Commissioners on the Municipal Board gave the public lighting to the Killarney Electric Light Company, whose contract commenced on Saturday last. The gas company also lighted up as usual, and it is stated will continue to do so until the matter is settled in a court of law. Killarney consequently presents a remarkably brilliant appearance. It remains to be seen who has got to pay the piper.

No Hocus-Pocus about It.—"There is no hocus-pocus about it," Prof. Ayrton remarked during the course of the reading of the paper before the Institution last week on "Transparent Conducting Screens for Electric and other Apparatus." He was standing at the side of an electromagnetic voltmeter with a white handkerchief in his hand. "I shake the instrument with my handkerchief and it reads 100 volts. I now connect it with the mains of the Westminster Company, and shaking it, it reads 40 volts, whereas the current in the mains is at 100 volts."

Gas and Electricity.—At the half-yearly meeting of the South-West of England District Association of Gas Managers, held at Salisbury, on Tuesday, a general opinion was expressed that, so far from the electric light having been a detriment to gas consumption, its introduction had really acted as a stimulus to managers and companies to increase the business, and perfect the utility of gas in every possible way. It is satisfactory to note that gas managers are discovering now that the electric light is not an enemy to them, but a friend. This is what we long ago pointed out to them.

Ichabod.—Serious fears have been entertained by Gog and Magog that the hoary fame of London town would be tarnished, if not absolutely obscured. Men wearing fustian and having short black pipes have busied themselves during these past few weeks or months with pick and shovel in rooting up the iron gas-lamp pillars that have lined the City thoroughfares for so many years. Now the only available sources of light on the streets are these long-legged, ghastly gallows posts with dazzling electric imps shut up in glass cases on top of them. Ichabod! for the glory of gas has departed.

Large Transformers.—A large order for transformers has been given out by the Cataract Construction Company to be used in the plant of the Pittsburgh Reduction Company at Niagara Falls. The apparatus will transform the two-phase current delivered from the station of the Cataract Company at 2,500 volts into continuous current at 160 volts for the use of the Reduction Company. There will be eight 200-kilowatt step-down transformers and four 370-kilowatt revolving transformers for transforming two-phase current into continuous current. It is believed that this will be the largest plant of the kind in the world.

Nuremberg.—In our last issue we referred to the fact that the street tramway company were waiting for the authority of the Municipality to construct an electric tramway system. The Municipality has now authorised the construction of an experimental line on the route from Maxfeld to the central railway station and the Plärrer head depôt, the experimental period not to exceed a year. It is also stipulated that the lines shall be built to the suburbs of Steinbühl and St. Johannis. The Municipality demands 2 per cent. of the gross receipts and a division of profits beyond 5 per cent. The tramway company estimate the cost of the introduction of electric traction at about 1,800,000 marks, or, say, £90,000.

Telegraph Material for India.—In the House of Commons on Monday, Mr. H. Fowler, in answer to Colonel Howard Vincent, said that competition for the supply of telegraph material for the Indian Telegraph Department and other branches of the India Office was not restricted to specially favoured houses. Any British or Irish firm that could satisfy the department of its ability to supply goods of the quality required would be placed on the India Office list of contractors, and would be invited to tender as opportunity arose. Experience had shown that it was not advisable to purchase stores of this description by public advertisement.

Patent Office Fees.—In the House of Commons last week Mr. A. C. Morton put a question on the subject of Patent Office fees. In reply, Mr. Mundella said that the number of applications refused by the law officers between July 1, 1852, and December 31, 1883, could not be given, no record of such refusals having been kept. The number refused by the comptroller of patents between January 1, 1884, and December 31, 1893, was only 146, and the value of the fees accruing to the Patent Office therefrom about £500. The number of patents voided, at one stage or another, through non-payment of renewal fees between July 1, 1852, and December 31, 1893, was 121,242, but no fees accrued to the Patent Office by reason of their expiry. The average life of a patent during the period named was about five years.

Electric Transmission of Power in Belgium.—The success of the installation at the Herstal Arms Factory at Liège, where the whole of the machinery is driven by electromotors, has given an impetus in Belgium to the industrial application of electric transmission. The Société de la Vieille Montagne, which at present have several steam-power installations at different parts of their works, are going to abolish them, substituting one large central station, from which power will be transmitted electrically to where it is required. It is expected that this arrangement will result in economies being effected. M. Pieper, of Liège, is at present arranging a railway carriage of the Belgian State Railways in order to make experiments in connection with electric traction on railway lines of the standard gauge.

Mix and Genest.—The annual meeting of the shareholders of the Actien-Gesellschaft Mix and Genest, of Berlin, took place on Monday, when the report was submitted and adopted. The result of the year's trade showed a gross profit of £17,435, and after writing off £3,910 for depreciation of plant, etc., and carrying to a reserve fund £500, the directors were able to declare a dividend of 8 per cent. on the paid-up capital. The constantly increasing business of this company has necessitated the building of a new factory, as the orders, more particularly for telephone exchange work, have required the renting of two additional factories. The new building has been designed with a view to centralise the manufacturing department, the estimated cost being £30,000, and the cost of acquiring the site, which is 6,653 square metres, is £17,000.

E.C. Company.—We are informed that the reorganisation of the staff at the works of the E.C.C. is now complete. Mr. A. B. Blackburn, M.I.C.E., late with Messrs. Mather and Platt, Limited, has been appointed to succeed Mr. T. Parker, and the work is going on as usual. Several important contracts have been lately booked by the company, and they are proceeding with the contracts for lighting Wolverhampton, Halifax, and Aberdeen. They have also just received the order for the electrical plant for Stafford, and have instructions from

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the County of London and Brush Provincial Electric Lighting Company to proceed with the plant for the Clerkenwell central station. We understand that the changes which the Board felt necessary to be carried out have all been for the interests of the company, and that the directors are confident that they will lead to economy and prove beneficial.

Coal-Mining by Electricity.—A series of trials of electric coal-cutting machinery has taken place this week at the Lidgett Colliery, Tankersley. Recently Messrs. Robert and Thomas Clarke, sons of Dr. Clarke, owner of the colliery, invented a coal-cutting machine to be driven by electricity. Subsequent trials were satisfactory, and the colliery company felt they would be justified in putting down suitable plant. On the pit bank is a pair of engines for driving a dynamo, and the current generated is conveyed underground to the machine, a distance of about a mile. The trials were made with a machine having a "cutting wheel" about 4ft. diameter. At the first day's trials the machine "holed" 40 yards of coal face, 40in. underneath, in a little over an hour. On Wednesday the work was even more satisfactory, the machine cutting 10 yards, 40in. deep, in 12 minutes, and when certain contemplated improvements are made, it is expected that it will cut a yard per minute. The trials were conducted by Mr. R. Clarke, Mr. Stevenson (electrical engineer), and Mr. Thompson.

Some Phenomena of the Upper Air.—At a meeting of the Royal Meteorological Society held on Wednesday, Mr. Richard Inwards, F.R.A.S., the president, delivered an address on some phenomena of the upper air. He said that there are three principal ways in which the higher atmosphere may be studied—(1) by living in it on some of the great mountain chains which pierce many miles into the air in various parts of the globe; (2) by ascending into it by means of balloons; and (3) by the study of the upper currents as shown to our sight by the movements of the clouds. Mr. Inwards said that whatever system of naming and classifying clouds be adopted, it should depend on the heights of the various clouds in the air, and he gave a few rough rules by which the comparative altitudes of the clouds may be judged when there is no time or opportunity to make exact measurements. Among the indications by which a cloud's height in the air may be gathered are its form and outline, its shade or shadow, its apparent size and movement, its perspective effect, and the length of time it remains directly illuminated after sunset. After showing a number of lantern slides illustrating the various types and forms of clouds, the aurora borealis, rainbows, etc., the president concluded his address by urging the desirability of establishing a good cloud observatory somewhere in the British Isles.

Photometry.—The third and last of the series of Cantor lectures on photometry was delivered by Captain Abney, C.B., F.R.S., at the Society of Arts on Monday. In his first lecture he had said that to get a constant light it was necessary always to have the same temperature throughout, referring, of course, to carbon lights only, and by means of the electric light and of the spectrum of the electric light he showed how this could be effected, using for the purpose an instrument which might be said to be of historic interest. This was the apparatus employed at the late eclipse for estimating the measurement of light of the corona—the method being that of the grease-spot. He next introduced another photometer, which he had himself devised. It was useful for a number of purposes, and he believed it to be original. The principal feature was the application of a screen in the form of a double cube, and by its means he had measured, amongst other things, the density of deposit on photographic negatives, and the amount of luminosity of coloured glasses, the light of a dark room, for instance. This led to the question whether the light reflected from surfaces could be measured, and he showed how this could be done in a simple manner, referring, as an example, to the measurement of the blackness of the image on the platinotype paper used in photographic printing. The light reflected from coloured surfaces could also be measured, and here we had the photometry of colour.

Electric Illumination.—The third lecture on this subject by Prof. Fleming was delivered at the Royal Institution on Tuesday. The lecturer commenced by describing the effects of age upon the light-giving qualities of incandescent electric lamps. He stated that, in general terms, a rise of resistance and decrease of candle-power were the results of changes taking place in the filament. Passing to the subject of arc lighting, he mentioned there were three modes of electric discharge—the incandescent discharge, the spark discharge, and the arc discharge. The two former modes pass spontaneously into the arc discharge if the pressure and quantity of electricity are great enough. The formation of an arc between carbon rods was then shown, and it was experimentally proved that the arc could not be started unless either the rods were first brought into contact or the insulating power of the air between broken down by an electric spark. An immensely magnified image of the arc was projected on the screen, so that its interior structure was rendered visible. It was seen, for instance, that the positive carbon rod becomes most intensely hot at the extremity and hollowed out into the form of a crater, from which about 80 per cent. of the total light is emitted. The negative carbon does not become so hot. The space between the two, or the true arc, is filled with vapour of carbon. In the central space a brilliant violet axis is seen, violet being the colour of incandescent carbon. Outside this is an aureole of carbon vapour of yellow or golden colour. With the use of a prism, the central axis of the arc gave a spectrum marked by two brilliant violet bands. It was next shown that the rise of electric pressure in the arc takes place chiefly at the surface of the crater, which is, in fact, the place where the work is done in evaporating the carbon. The light emitted is, therefore, due chiefly to the incandescence of the carbon in the crater. Hence the light is not given off equally in every direction. It is most intense in that direction in which the largest area of crater can be seen. The subject of arc lamp mechanism was then lightly touched upon, and a number of varieties of arc lamps exhibited in action. In conclusion, the lighting of streets by arc lamps was discussed.

Electric Cooking in the Metropolis.—As stated in our last issue, a series of demonstrations of electric cooking and heating has been commenced at the showrooms of the London Electric Supply Corporation, Belgrave-mansions, Ebury-street, under the auspices of Messrs. Crompton and Co. It appears that this is only the commencement of a new departure about to be made by the metropolitan electric supply companies, who propose to encourage the use of current for the purposes mentioned. With this object in view it is intended, according to a statement in the *Pall Mall Gazette*, to lease out to consumers electrical appliances in the same way as the Gas-light and Coke Company have done in the case of gas appliances. Mr. R. E. Crompton, who has been interviewed at the above address by a representative of that paper, gave some particulars as to cost. With regard to improvements since the Crystal Palace Exhibition, Mr. Crompton said: "We have spent thousands of pounds in experimenting and in rejecting before we really got the secret of the

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thing, as I may say we have now. The Americans are generally supposed to have invented this notion, and we to have stolen it; but, as a matter of fact, we are miles ahead of anything they have got in America, and I fairly startled an American who came to see our things fresh from the Chicago Exhibition. He refused to believe his eyes. The most important discoveries we have had to make relate to the enamels in which the wires are bedded, and to certain dry processes of manufacture. It was thought to be impossible for a long time to get an enamel that would resist the very high temperatures required without softening. We have found one at last, and now we use three kinds of enamel. First of all, a coating of the hardest enamel is laid on the iron plate, and the little conducting wire is spread upon it. Then a second coat of enamel, not quite so hard, is laid over that, and, finally, a coat of decent white enamel is spread over all. The difficulty used to be to put on the second layer without melting the first, and allowing the conductor to sink through and touch the iron plate. Another important change we have made is the substitution of nickel-steel wire for copper or some other metal, which was used at first. But the thing which has really settled the business and made the industry a practicable one is a method we have devised for crimping and laying on the fine wire by machinery on to a dummy plate and so transferring it bodily to the enamel. Formerly it used to be laid on by hand, a difficult matter at the best, and most trying when you are dealing with hot layers of liquid enamel. Now we have got over this, electric cooking apparatus is as easily made as tinware."

Some Properties of the Electric Discharge Through Gases.—A discourse on this subject was given last Friday at the Royal Institution by Prof. J. J. Thomson. His first experiments were devoted to showing the reluctance of the electric discharge to pass from a gas into a metallic electrode. In one of the experiments by which he illustrated this a bulb was employed into which two long electrodes projected. The discharge between these was not from point to point, but from the point of one to the base of the other, the electricity keeping in the gas as long as possible. He then showed how the states of electrification in a bulb through which an alternating current is being passed vary according to the gas and electrodes used. Oxygen gives a strong positive electrification, while with hydrogen it is different in different parts of the bulb. The discharge from an electrode of oxide of copper in hydrogen is negative till the oxide is reduced, when it becomes positive. Such results seem to afford some support to a theory of the fundamental identity of chemical and electrical action. Prof. Thomson then went on to consider the discharge through gases without metallic electrodes, and for this purpose used the rapidly alternating current which flows in a wire connecting the outsides of two Leyden jars, the insides of which are connected with a Wimshurst machine. This wire was made into a coil, in the centre of which were placed bulbs containing the gases to be experimented upon. When two gases were to be compared in respect of conductivity, etc., the wire was made into two coils, in one of which the gas to be tested was placed and in the other a standard bulb. The brightness of the discharge in the latter gave an indication of the amount of energy absorbed by the former, or, in other words, of its resistance. From this and other experiments resembling those of Mr. Tesla, the lecturer deduced the conclusion that the conductivity of gases at a certain degree of rarefaction is greater than that of any metal, and almost infinitely greater molecule for molecule. At a higher degree of rarefaction, however, conductivity is diminished, and in a perfect vacuum, as has been shown by some of Prof. Dewar's experiments, it is probable that the discharge would not pass at all. Prof. Thomson showed that when a vacuum bulb was enclosed in a vacuum jacket which had been made with mercury and the whole apparatus placed inside a coil, the discharge occurred only in the inner bulb. But upon increasing the density of the mercury vapour in the annular space the discharge took place there instead of in the inner bulb. Whatever deduction may be made from this experiment it is clear that the annular space in both cases is permeable by electric force—in other words, that electric currents cross a high vacuum quite freely, though they produce no glow to indicate the fact. The last experiment performed referred to the influence of a magnetic field on the discharge, which was shown to take place more easily along the lines of magnetic force that across them.

The Hamburg Electric Tramway.—As we have already briefly noted, the circular electric tramway at Hamburg was set in operation a short time ago. It was originally intended that the work should have been completed in November last, but the difficulties in connection with the project were greater than had been anticipated, so that delay ensued. Running was commenced at the end of February, and a month later the Union Elektricitäts Gesellschaft of Berlin, which had carried out the work, invited a large party of tramway men and others to inspect the line, an account of the visit appearing in the *Elektrotechnische Zeitschrift*, from which we obtain the following particulars. The line is constructed on the well-known Thomson-Houston system, which has already been employed in Germany on the Bremen line. At present only the circular tramway is operated electrically, but very shortly two further lines will be equipped. The circular line, which surrounds the old town, is nearly five miles in length, and contains some steep gradients, sometimes as high as 1 in 15. The line is of double track throughout, and there is a five minutes' service in each direction. There are 14 cars in use, making a total of 308 journeys per day. Copper conductors, 8·25mm. in thickness, are carried 20ft. above the tramway lines and longitudinally therewith. These are suspended by insulators to transverse steel wires which are supported either by iron posts, or in narrow streets from the houses. In the newly-widened street at the harbour, however, ornamental posts have been erected between the tracks, which carry arms on each side supporting the copper conductor. The street lamps here have also been placed on these ornamental posts. Where many telephone wires cross the street, the conductor is surmounted by a small protecting wooden roof, the reason being that shortly after the opening of the electric railway a telephone wire gave way, fell on the conductor, and caused a short-circuit. Current is received from the central station in the Poststrasse, which also supplies current for the lighting of the town. The central station furnishes lighting current on the three-wire system at 300 volts pressure, but the tramway requires current at 600 volts. Therefore two Schuckert transformers of 170 h.p. have been installed at the central station, and there has also been erected a 170-h.p. steam-engine directly connected with a dynamo made by the Union Elektricitäts Gesellschaft. The cars run from seven in the morning until midnight. Each car is lighted by five incandescent lamps inside. The carrying capacity of each car is 30 exclusive of driver and conductor. When the two new lines from Vaddel to the Schlump, and from the Pferdemarkt to Eimsbüttel are opened, the total length of electric line will be about 13 miles. Both the new lines will, on part of the route, traverse portions of the circular line. The tramway company is working the line on its own account, but has certain guarantees from the Union Elektricitäts Gesellschaft.

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ELECTRIC TRACTION ON LONDON RAILWAYS.

BY FRANK B. LEA.

(Concluded from page 436.)

We have said that there are, roughly speaking, five great railway systems in the metropolitan area upon which the shuttle or circular form of passenger traffic may be found to some considerable extent, and it will, perhaps, be advantageous at this point to set them forth in such detail as will be useful and expedient, having in view throughout the question of possibly substituting electric working for steam traction upon these lines with some reasonable amount of success. It need hardly be said in reference to this that the cost of conversion, and the estimated monetary value of benefits accruing from improved methods, will prove the main factors in any decision to be reached.

I.—UNDERGROUND SYSTEM.

Lines.	Weekday trains daily each way.	Working hours.	Average equivalent service, each way.
A. Circle trains:			
King's Cross, Aldgate, Charing Cross, Kensington (High-street), and *vice versâ*.	—	—	10 min.
B. Shuttle trains:			
1. New Cross to Putney and Wimbledon.	73 west	5.30 a.m.	20 min.
	73 east	12.30 a.m.	
2. New Cross to Richmond, *vid* Mansion House.	31 west	5.50 a.m.	30 min.
	28 east	12.30 a.m.	
3. Whitechapel to Ealing, *vid* ditto.	63 west	5.30 a.m.	20 min.
	58 east	12.50 a.m.	
4. Aldgate to Mansion House, *vid* Addison-road (Outer Circle).	39 west	5.45 a.m.	30 min.
	39 east	12.50 a.m.	
5. New Cross to Richmond, *vid* King's Cross.	80 west	5.15 a.m.	15 min.
	78 east	12.30 a.m.	

II.—METROPOLITAN EXTENSIONS: NORTH AND SOUTH.

1. Moorgate-street to Victoria, *vid* Brixton (L.C. and D.R).	71 west	4.0 a.m.	20 min.
	69 east	1.0 a.m.	
2. Moorgate-street to Crystal Palace (high level) and Greenwich, *vid* Nunhead.	62 south	5.0 a.m.	20 min.
	58 north	12.45 a.m.	
3. Victoria to ditto, ditto.	30 west	6.10 a.m.	40 min.
	27 east	12.45 a.m.	
4. Moorgate-street to Clapham Junction.	12 west	7.50 a.m.	Hourly.
	13 east	8.30 p.m.	
5. Moorgate-street to Tottenham and Hendon (Mid. R.)	81 south	5 a.m.	15 min.
	80 north	12.45 a.m.	
6. Moorgate-street to Alexandra Park (G.N.R.).	27 south	7 a.m.	30 min.
	31 north	12.45 a.m.	
7. Woolwich to Finsbury Park (S.E.R.).	9 each way	5.30 a.m.	1½—2 hours.
		11.15 p.m.	
8. Ludgate-hill to Richmond and Wimbledon (L. and S.W.R.).	27 west	6.50 a.m.	30 min.
	27 east	10.30 p.m.	

III.—NORTH LONDON.

1. Broad-street to Mansion House and Richmond, *vid* Hampstead and Willesden.	74 west	5.15 a.m.	15 min.
	74 east	11.45 p.m.	
2. Broad-street to Chalk Farm.	—	5.30 a.m.	15 min.
		12.15 a.m.	
3. Broad-street to Bow and Poplar.	—	5.15 a.m.	15 min.
		12.30 a.m.	
4. Broad-street to Alexandra Park (G.N.R.).	15 south	7.15 a.m.	45 min.
	19 north	8.45 p.m.	

IV.—GREAT EASTERN: SUBURBAN LINES.

1. Liverpool-street to New Cross and Peckham Rye, *vid* Wapping	49 south	4.50 a.m.	20 min.
	49 north	11.45 p.m.	
2. Liverpool-street and Fenchurch-street to North Woolwich	85 west	5 a.m.	15 min.
	90 east	1 a.m.	
3. Fenchurch-street to Blackwall.	—	5.20 a.m.	15 min.
		12.30 a.m.	

V.—SOUTH LONDON.

London Bridge to Battersea Park and Victoria, *vid* Peckham	66 west	4.45 a.m.	20 min.
	70 east	12.45 a.m.	

The lines and routes thus detailed, though with a confessedly imperfect classification, are such as appear from their traffic to be most suited for electric working throughout the London suburbs; and where others might, perhaps, be thought equally fit for inclusion in the list, it will be found either that the traffic is unimportant or infrequent, or else that main-line working demands the first consideration. This latter point would prove an almost insuperable difficulty with regard, say, to the South-Eastern, Brighton, South-Western, Great Eastern, Great Northern, and other main-line suburban services other than those already included; and even on many of the routes in the table, obstacles might arise in this way. For instance, express main-line traffic is worked to some extent upon systems II. 1, II. 3, II. 5, II. 8, and would have to be allowed for accordingly. It might even prove impossible to arrange such joint working; for obviously in the cases above mentioned, the companies interested would consider that a breakdown of the electric service might at any time seriously affect their main-line traffic.

The London, Chatham, and Dover expresses from Victoria through Brixton, the Midland trains through Kentish Town, and the Brighton Company's Portsmouth services would all be running for short distances upon lines also used by trains which might advantageously be operated by electric motors. Complete separation of the fast and slow traffic is, of course, desirable, but the difficulty and expense of building even a single additional line must prove in many cases almost prohibitive. In this connection, it seems quite time that some capable engineer should take in hand the planning of a double-decked system, by means of which the capacity of many lines now overcrowded might be nearly doubled without going to the enormous expense of buying fresh land in populous suburbs. A successful instance of this type of line is to be seen in the Liverpool Overhead Railway, where a surface railway runs underneath the superstructure for nearly its entire length.

Turning, now, to the table of systems shown, it will be seen at once that, with the exception of the Inner Circle trains running every 10 minutes, the headway between trains on any particular route is by no means short, the average number of trains all round not being really more than about three per hour. Of course, the reason for this will also be obvious: it is due simply to the fact that certain parts of the route are used by several services, and the trains must therefore be sandwiched or fitted in one after another in the most convenient way. An observer watching the trains that pass eastward through, say, Blackfriars Station, on the Inner Circle, will not have to wait more than five minutes at the outside to count each train; the average will be nearer three minutes. At such points the lines are fully crowded, and the remedy—if a better and more frequent service is desired—is twofold: either the lines must be doubled—a practical impossibility on account of the cost—or else greatly improved methods of working the traffic must be introduced.

This may be done in two ways with a material saving of time. By the use of electric traction a much higher average speed may be maintained, judging from the experience gained on the Liverpool Overhead Railway; this, of course, is partly due to the greater ease of starting and stopping when a rotary motor is employed. The corresponding economy in fuel, etc., is by no means an unimportant consideration, but need not be dealt with here.

Secondly, a materially diminished headway between the trains is obtainable by the use of automatic electric signalling, instead of the ordinary manual system of operation. Here, again, is a great saving in money as well as time; but we are at present dealing more especially with the latter. So far as the underground lines are concerned, it appears pretty evident that if the services now being operated—as shown in the table, on a 20 or 30 minute headway—are to be materially quickened, this result can only be accomplished by the use of electric traction and automatic electric signalling. Similar remarks would apply to the lines which form the extensions of the Metropolitan Railway through Snow-hill to the South of London, and in all cases, indeed, where a number of distinct services are obliged to use the same lines, even over a short distance.

Where a route is more or less isolated—as, for instance, Fenchurch-street to Blackwall—the question resolves itself rather into deciding upon the relative advantages of light trains at frequent intervals, or heavier trains on a longer headway. Of course, a high efficiency of electric traction is best obtained with services running, say, two or three car trains every five minutes, rather than nine-car trains at intervals of a quarter of an hour—that is, to make the line a tramway rather than a railroad. For suburban service, where frequent stops are required, one would say that this tendency is right and proper, and deserves to be fostered.

Questions of cost—either as regards capital outlay or working expenses—are not now touched upon in any way.

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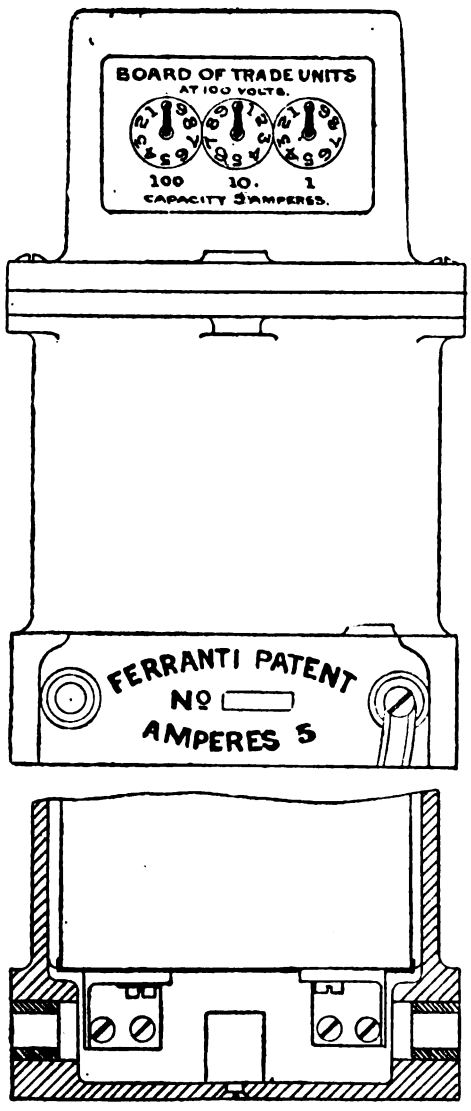
When the time comes for engineers to submit estimates, it may be taken for granted, however, that they will be ready to convert these or other lines, and operate them, if required, on a basis which will show considerable economy of working over the present systems, whilst the monetary value of increased public ease and comfort will represent by no means a small percentage upon the capital expenditure required for the proposed change.

ELECTRICITY METERS.*

BY R. P. WILSON.

(Continued from page 439.)

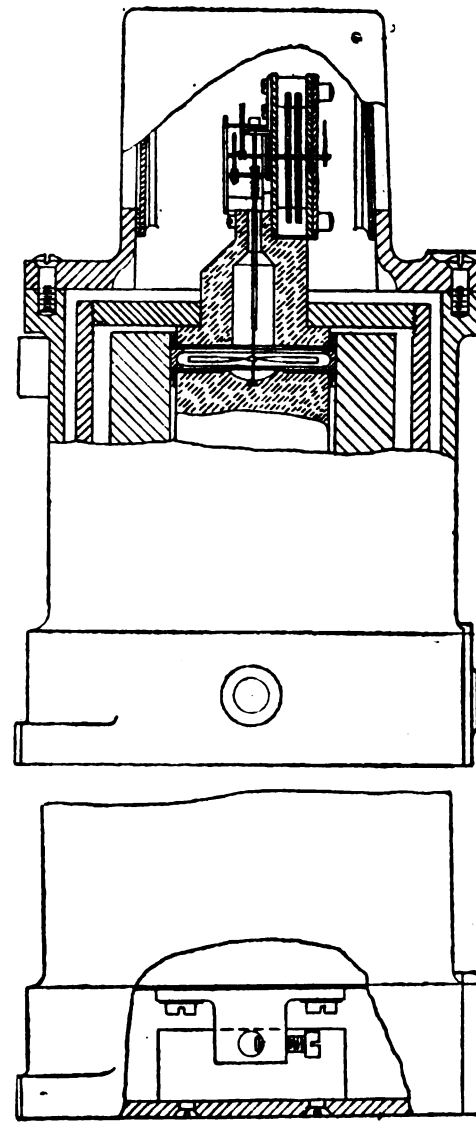
(3) *The Shallenberger Alternating-Current Ampere-Hour Meter.*—This meter, which is the invention of Mr.



Ferranti Meter.

Shallenberger, one of the engineers of the Westinghouse Company, is one that has undergone probably less modifications than other meter in the market, excepting the Edison. Its action may be explained as follows: The current to be measured passes through the series coils, inside which is what may be described as a short-circuited secondary coil fixed with its axis at an angle of about 45deg. from that of the series coil. Enclosed in both these coils is a soft-iron ring mounted horizontally on a vertical shaft. The current in the series coil induces in the short-circuited secondary another current, in which the current lags a quarter of a period, with the result that these currents, which are continually reversing, produce rotation in the iron ring, which communicates its motion to the registering mechanism. In this meter the velocity attained is approximately proportional to the square of the speed, and the square root is extracted by the resistance offered by the air to the revolution of a four-winged aluminium fan mounted at the lower extremity of the shaft. It may be well to point out that the retardation produced by any such fan varies with the barometric pressure—that is to say, with the density of the atmosphere. The meter, however, is very largely used with very satisfactory results, but only in comparatively small sizes, as far as the author is aware.

(4) *The Ferranti Direct-Current Meter.*—The rotation of this meter is produced by passing a current radially through a bath of mercury situated in a magnetic field. Immersed in the mercury is a fan attached to a vertical shaft, which communicates its rotation to the registering mechanism. The torque produced by the current in the series coil which is used to establish the magnetic field above referred to and



Ferranti Meter.

to pass through the mercury, would produce a rotation whose velocity would be proportional to the square of the current. This is retarded by means of the fluid friction set up by the moving of the mercury against the side of the vessel containing it; this fluid friction corresponds to the fans in the case of the Shallenberger meter. A meter on this principle was originally invented and exhibited by Lord Kelvin at the Health Exhibition. Since that time Mr. Ferranti made, with a certain amount of success, some alternating-current meters on the same principle, but they were not commercially as successful as the direct-current type, and have since been abandoned. The initial friction in this meter is counteracted by making the core of the solenoid on which the series coil is wound a permanent magnet, which takes the place of a shunt circuit such as is generally used. A great deal of difficulty was experienced in getting mercury that was chemically pure, and in preventing the rusting of the steel shafts, but the author has been given

* Paper read before the Northern Society of Electrical Engineers, April 9, 1894.

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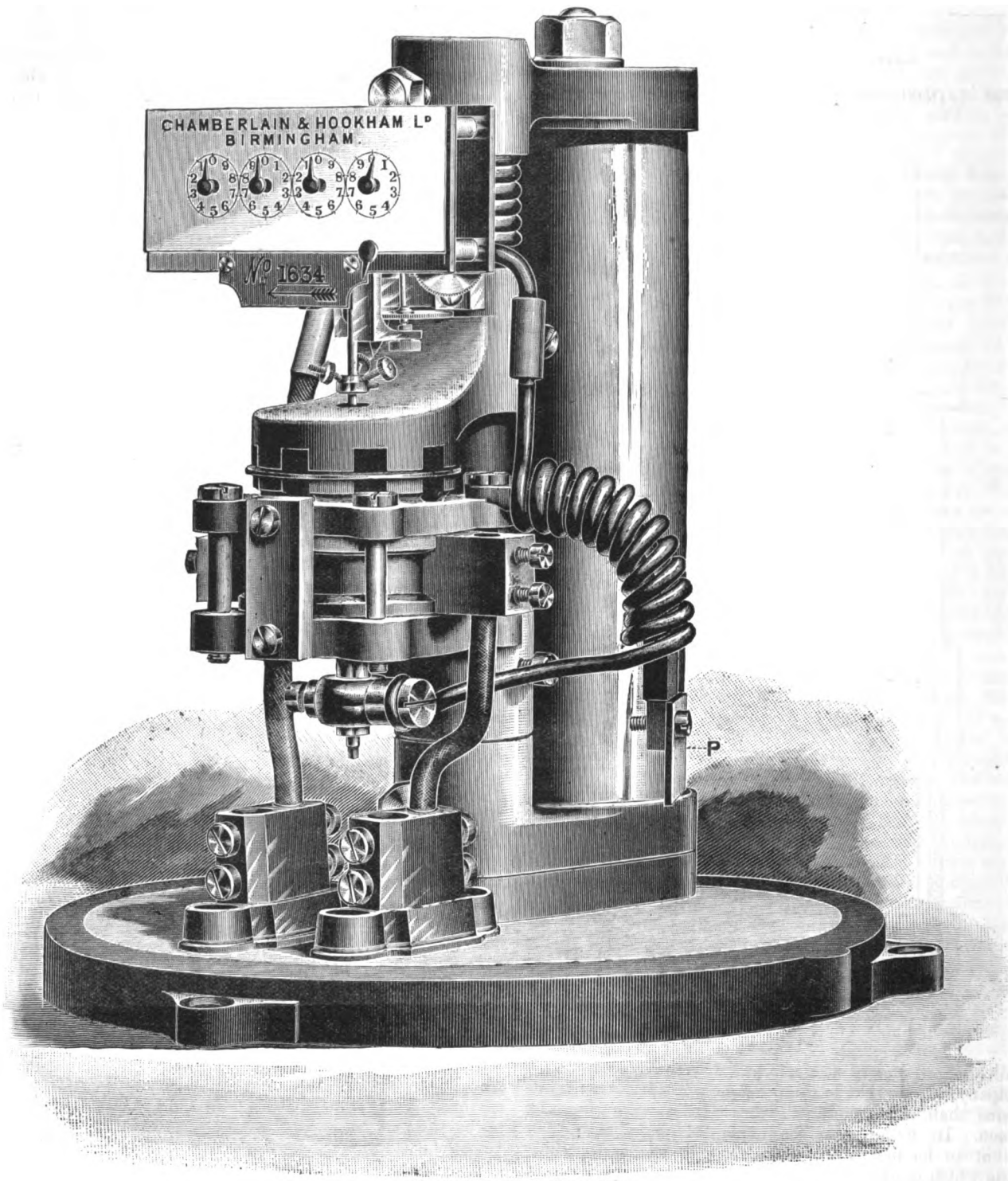
to understand that these difficulties have since been overcome by methods which Mr. Ferranti is evidently anxious to keep to himself, as a request for further information on this subject elicited no reply. These meters are manufactured in a very neat compact cast-iron case, and they were the first to contain the double sealing arrangement which, although suggested by the Board of Trade, had been adopted by Mr. Ferranti before that time.

(5) *Chamberlain-Hookham Meter.*—The older form of this meter was very similar in principle to the Thomson, in that the retarding arrangement consisted of a copper disc revolving between the poles of a permanent magnet. The motor part consisted of a number of coils wound flat and fixed to the copper disc, the current being carried to the armature coils by means of a commutator rotating in mercury-cups. The action of the instrument was thus a motor in which the armature carried the current to be measured, and a constant field in the form of a permanent magnet. This form of meter has, however, been entirely superseded by the new type, which is almost a different meter altogether. Like the Ferranti, it consists of a mercury-bath carrying a disc through which the current to be measured travels radially, the intensity of the field being varied by a series coil wound on one of the cast-iron polar extensions, and a further winding wound on an iron bar attached to the cover of the bath, so that the total induction through the permanent magnets remains practically unchanged. A very ingenious device for reducing the friction of the rotating disc consists of attaching to the disc immersed in the mercury a second disc of vulcanised fibre,



Chamberlain and Hookham Meter.

which, owing to its small specific gravity compared with that of mercury, tends to reduce the weight on the lower bearing. The difficulty of rendering permanent the magnets so largely used now in this and other meters has been practically overcome, so that there is no objection to their use.

Before leaving the subject of meters altogether, it may be well to mention the Ferranti-Wright meter, but as this meter is not very largely used it will be unnecessary to devote more than a very few words to it. The series coils

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and shunt coils are wound on cores of laminated wrought iron having elongated polar projections, between which is placed a closed metallic ring. The progressive poles in these elongated pole-pieces alternate successively, and thereby produce rotation in the conducting disc which is proportional to the square of the current, the retardation being induced by means of a fan, as already explained. This meter depends for its action partly on the hysteresis in the iron, and partly to the reaction of the current in the metallic ring revolving between the poles.

(To be continued.)

A NEW WIND MOTOR FOR ELECTRIC LIGHTING PURPOSES.

An exhibition was made at Willesden Junction on Tuesday afternoon of the Rollason wind motor, an appliance intended for the operation of dynamos for electric lighting and power purposes. A large party of guests assembled in response to invitations issued by the

directors of Rollason's Wind Motor Company, Limited, of 13, Berners-street, to witness the motor at work, but as the wind was unfavourable the motor could not properly be shown in action. Previous to the demonstration of the motor, luncheon was served at the Royal Oak Hotel, Harlesden, when Mr. Fletcher and Colonel Brown, two of the directors of the company, expressed themselves very sanguinely as to the possibilities of the appliance. It was mentioned, in so far as the electrical arrangements are concerned, that Messrs. Edmundsons, Limited, of 19, Great George-street, Westminster, had co-operated with the company in bringing the Rollason system to its present position. The motor, which is arranged in a field close to the Junction, has been erected for about two months, and its efficiency, although no figures were forthcoming, is claimed to be high.

Observed from the train, the motor presents somewhat the appearance of an elevated bandstand. Its form differs materially from the ordinary method of constructing windmills as seen in rural districts, and from the type of windmill used experimentally for electric lighting purposes near the Cap de la Hève, on the French coast, or in the United States. The Rollason system may be divided into two parts—the mechanical arrangements of the wind motor, and the electrical plant and accessories. As far as the electrical portion of the system is concerned, the special features claimed are the methods adopted for disconnecting the dynamo from the accumulators when the wind drops, for charging and lighting simultaneously, and for stopping the dynamo when the accumulators are fully charged and for restarting it as soon as any current is taken from the accumulators. The object of this is to allow the combined motor and electrical plant to work all night without any attention. The details of these arrangements form the subject of pending patent rights, and of which little can be said at the moment.

With regard to the motor—an illustration of which is annexed—it will be noticed that it is a horizontal arrangement contained in a skeleton turret. From the top to bottom of the centre or axis of the turret is provided a vertical steel shaft; this has attached to it five concave sails, which revolve on radius rollers immersed in oil. On these sails are fixed a number of inclined ridges or planes, which it is claimed deflect the force exerted by the wind to their peripheries. Between the sails and the shaft is arranged a considerable open space which allows the wind to actuate simultaneously three sails out of the five. Outside the sails is a framing, or screen, supported by six radial or cross arms, which are bolted to a centre bearing, which is free to rotate independently of the sails. A second vertical shaft from the top of the shield is continued through the roof of the turret, and to this is fixed a vane, so that when the direction of the wind changes, it moves the shield into the correct position for only the concave sides of the sails to catch the wind. On the top of the sail shaft is fixed a cup containing a quantity of oil, within which are rollers, by which the shaft actuates the shield. The weight of the vane shaft is carried on an independent roller bearing fixed in the roof of the turret. The whole weight of the sails and framing carrying the shield is thrown to the centre bearings on the bottom of the turret, which thus gives to the working parts of the motor the desired balance.

The motor at the Junction is 20ft. in diameter, and is erected on an open iron structure 30ft. high. The power developed by the motor is transmitted by a vertical shaft running down the centre of the supporting framing into a wooden shed on the ground. Suitable gearing is provided on the lower end of the shaft for working the pulleys actuating by belting an Elwell-Parker dynamo, which is used to charge accumulators.

The company claim for the Rollason motor simplicity, efficiency in working, and that it can be left working for a lengthy period without any attention.

THE JOEL ALTERNATING-CURRENT MOTOR.

The alternating-current motor devised by Mr. Joel was illustrated and described in the *Electrical Engineer*, June 2, 1893. This motor has been tested at the Electrical Standardising, Testing, and Training Institution by Mr. H. E. Harrison, who has prepared a report on the efficiency of the motor. The following is a copy of the report, dated April 16, 1894.

"In accordance with your instructions, on the 12th inst. we took the readings, which are given in the table below. The alternating-current motor from which the results were obtained, was in each case run under the conditions arranged by your representative. The readings were taken by ourselves, and the instruments were afterwards compared with our standards.

Revolutions per minute.	Watts.	Electrical horse-power.	Brake horse-power.	Percentage efficiency.
1,582	1,160	1·55	0·454	29·2
1,390	999	1·34	0·354	26·4
1,263	950	1·27	0·316	24·8
1,259	950	1·27	0·314	24·7
1,296	877	1·17	0·420	35·7
1,324	877	1·17	0·429	36·6
1,490	900	1·20	0·482	40·0
1,472	950	1·27	0·477	37·6
1,506	1,020	1·365	0·465	34 0

"The motor is self-starting, and can be reversed by means of an ordinary reversing switch. The starting torque measured with the armature at rest, is $3{\cdot}925 \times 10^7$ C.G.S. units as compared with $2{\cdot}257 \times 10^7$, the torque when the motor is running so as to give 40 per cent. efficiency."

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A BRILLIANTLY-LIGHTED AVENUE.

About a year and a half ago the low-tension system of street-lighting was introduced for the first time in New York on Fifth-avenue. It had been found, the *Electrical World* says, that some such device must be resorted to, for series arc lamps were little demanded on that avenue for commercial purposes, and the expense of laying the wires for conduits for street-lighting alone was so great as to be practically prohibitive. Accordingly the Edison Illuminating Company solved the difficulty very satisfactorily by employing a low-tension system, in which a pair of arc lamps on each post were used instead of a single lamp with dead resistance, as had been the case in previous attempts at low-tension arc lighting. Each of these lamps, which were of the Bergmann type, manufactured by the General Incandescent Arc Light Company, took five amperes at approximately 50 volts, so that practically the same amount of energy was used as in the high-tension arc lamp on the series circuit. The low-tension system also possessed a number of advantages over its older rival. In the first place, it was possible to connect the lamps directly to the Edison low-tension mains, thus effecting a great economy and adding to the convenience and flexibility of the system; secondly, the light was more effective on account of better diffusion, as the casting of shadows was practically obviated.

An ornamental post was employed made in three parts: the base, the shaft, and the arm section. Instead of placing the resistance in the hood of the lamp it was located in the base, and the lamps were lowered and raised from within the shaft, to which access was had by means of a door in the base, the key of which was carried by the trimmer. The lamps are fed by a sliding contact, so that when they are lowered the current is entirely shut off and the trimmer is perfectly safe from even a low-tension shock. The lamps are supplied from the mains by the ordinary house service method, wires running through the gas-pipe which forms the centre part of the shaft.

One of the great advantages of this system of lighting is the ornamental appearance of the posts and the lamps, which greatly surpass in this respect the older type of series lamp. This system has been found to operate most satisfactorily during the past 18 months, and the only criticism passed upon it was that the avenue was not as brilliantly lighted as had been anticipated. The Edison Company recently decided to overcome this difficulty by doubling the number of lamps, and accordingly have inserted at the centre of each block another post carrying two lamps. There are now 114 posts, which, with two lamps each, makes a total of 228 lamps. This has had the desired effect, and Fifth-avenue is one of the most brilliantly illuminated thoroughfares in the city. At the same time the light is much more soft and pleasing than that which is given by high-tension lamps.

A MODIFIED INSTRUMENT FOR THE DETERMINATION OF THE $\mathfrak{B}\,\mathfrak{H}$ CURVES OF IRON.*

BY H. W. SCHROEDER.

An article on this subject, which appeared in the *Electrical World* of February 24, 1894, called to my mind a very simple method invented by myself some time ago for measuring the relative permeability of different grades of iron.

I use a soft J-shaped yoke, between the legs of which is placed the piece of metal to be tested, and around which is wrapped the exciting coil. At the curved end of the yoke is placed a coil, which is connected to a voltmeter reading from one to one hundred volts—in fact, my instrument may be looked upon as a simple transformer, from which the primary core may be removed and replaced by the cores to be tested. We will treat it as such, and will call the coil surrounding the removable core the primary, and the coil at the bent end of the yoke, with which the voltmeter is connected, the secondary.

* From the *Electrical World*.

Now, it follows that if a piece of iron, the permeability of which is high, be placed between the legs of the yoke and used as a primary core, and an exciting current sent through the primary coil surrounding this, there will be a current induced in the secondary coil; and if this exciting current be increased until the voltmeter indicates 100 volts and be maintained constant, we can then replace our high-permeability core with one we desire to test. All the conditions now being the same as at first, except the primary core which we are testing, the voltmeter in the secondary will indicate in proportion to the number of lines of force cutting the secondary coil. The number of these lines of force depends upon the permeability of the metal being tested, and if the voltmeter now indicates but 75 volts we may know that the permeability of that piece of iron is but 75 per cent. of that of the first. Such an instrument as this is very easily constructed, the only part not readily at hand in almost any workshop or laboratory being a standard bar to compare with, but even this is not necessary where it is only wanted to determine the best of a few samples of iron. Of course, it is understood that an alternating current is used as an exciting current, and that any alternating-current voltmeter will do for use in the secondary.

I might add that where it would be inconvenient to maintain a uniform exciting current, two of these instruments (just alike) could be used, one for the standard bar and one for the iron to be tested, the primaries being connected in series, thus taking the same current. Two voltmeters would be used, one in each secondary, and compared directly with each other. For further accuracy, the standard to be tested could be changed from one instrument to the other and the voltmeters compared again.

AN ASTATIC STATION VOLTMETER.*

BY W. E. AYRTON, F.R.S., PAST-PRESIDENT, AND T. MATHER, ASSOCIATE.

The rapid development of electric lighting generating stations during the past three years has resulted in a greatly increased perfection in the regulation of the pressure, and consequently has created a need for measuring instruments of much greater precision than was previously required. At the same time, the powerful dynamos now employed, and the large currents that flow through the mains on the switchboards at these generating stations, has greatly increased the disturbing influences to which electromagnetic measuring instruments are subjected. Consequently, it is not to be wondered at that voltmeters and ammeters which answered fairly when the output of the stations was small have had to be discarded as being unsuitable for the present requirements. The authors have, therefore, been engaged for some time past in developing an electromagnetic voltmeter to fulfil the following conditions: (1) be unaffected by an outside magnetic field, whether uniform or not, and as strong as the disturbing magnetic field on any ordinary central-station switchboard; (2) be unaffected by an outside electrostatic disturbance, such as is produced on rubbing the glass front of the instrument; (3) have no temperature error; (4) have a high resistance, so as to measure equally accurately the true pressure at the end of long thin pilot wires, or in the station itself; (5) have a scale of large radius, and one very open at the working pressure, so that a small change in the pressure can be detected; (6) be dead-beat.

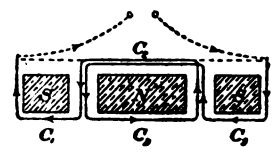

FIG. 1.

Condition No. 1 is most easily fulfilled by employing a powerful stationary permanent magnet and a moving coil, for such an arrangement has the great advantage that it cannot indicate a pressure unless a current be actually flowing through the coil; whereas soft iron and other types of voltmeters, when placed in a fairly strong magnetic field, may have the pointer deflected across the scale when no current whatever is passing through the instrument. But it is not sufficient to merely employ one permanent magnet and one moving coil, as is proved by the fact, which is probably not generally known, that the very beautiful Weston voltmeter, in spite of the permanent magnet being strong and the air-gaps in which the coil moves being extremely small, indicates slightly differently when put in different positions

* Paper read before the Institution of Electrical Engineers, April 12.

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in a magnetic field even as weak as that of the earth's, the change in the reading being about ½ per cent. when the instrument is placed horizontally and turned through an angle of 180deg. in a horizontal plane.* This voltmeter therefore cannot, of course, give constant indications in a varying magnetic field 50 or 100 times as strong as that of the earth's. Now Messrs. Clark and Malpas have found, by experimenting with our portable magnetic field tester, that a field of 20 C.G.S. units, or one rather more than 100 times as large as that due to the earth, is the sort of magnetic disturbance that occasionally occurs on the switchboards of existing central stations, while fields of six C.G.S. units—that is, 30 times the earth's field—are quite common.

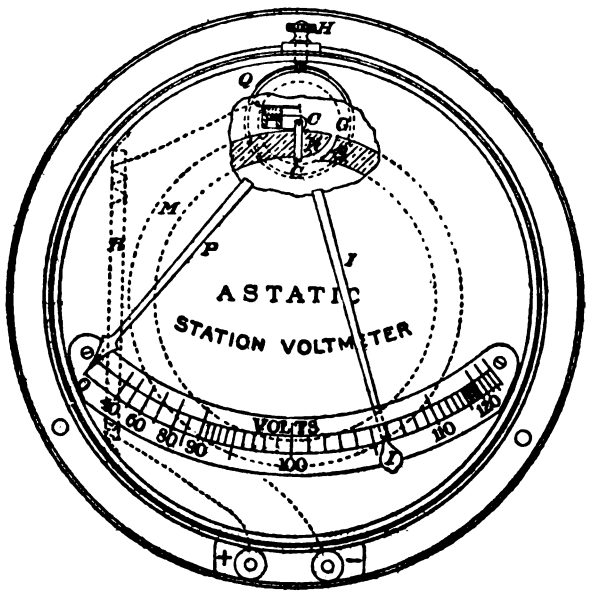

FIG. 2.

If the coil be wound astatically, and be acted on by two powerful permanent magnets inside the voltmeter, with their poles oppositely directed, good screening can be obtained from a uniform disturbing magnetic field; but errors will be produced if the disturbing field be non-uniform, such as is caused by a mass of iron, or by a conductor carrying a current, placed near the voltmeter. We have, therefore, carried this principle of astaticism further by employing three permanent magnets and a coil wound in three parts, as shown diagrammatically in Fig. 1, the area of the middle coil being double that of either of the end ones; and in this way we have obtained an arrangement which is comparatively unaffected by either a uniform or a non-uniform magnetic disturbance.

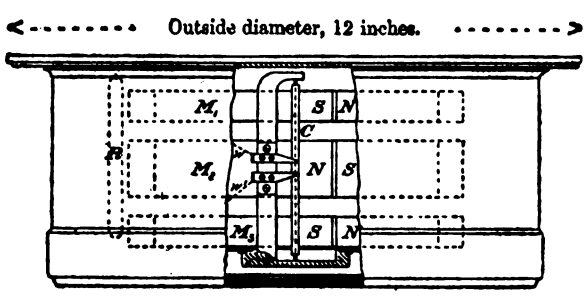

FIG. 3.

The moving coil principle also enables conditions 3 and 4 to be fulfilled, for the resistance of this 100-volt instrument is about 7,000 ohms; and as only 3 per cent. of this is composed of copper wire—viz., that wound on the moving triple coil—while 97 per cent. is of manganin wire, indicated by the stationary coil, R, in Figs. 2 and 3, the temperature error is practically negligible. This high resistance also causes the power required to actuate the voltmeter to be very small, not more than about 1½ watts being absorbed at 100 volts with this voltmeter.

The control is produced by a weight, because this is the method of exercising a controlling force that is least likely to vary, and because the objection to the employment of a gravity control—that the voltmeter cannot be used in any position—is of no importance in the case of a switchboard instrument.

Fig. 2 shows the voltmeter in elevation, while Fig. 3 gives a plan; both figures being drawn partly in section, so that the working parts may be more clearly seen. The triple coil, C_1, C_2, C_3 (Fig. 1), passes over the poles of the three magnets, M_1, M_2, M_3 (Fig. 3), the direction of the winding being such as to cause the deflecting forces for each portion of the coil to be in the same direction. The current is led up to and away from the coil by very thin flexible silver strips attached to the points of the stationary pieces, *w w'* (Fig. 3).

Conditions 5 and 6 are satisfied by specially shaping the air-gaps, and we find that without sacrificing the quickness of motion of the pointer, P, too much, we can flatten the calibration curve a the working part of the scale so that 1-100th part of a volt variation in the pressure can be detected.

A bit of the scale is seen in Fig. 4, and although large and bold an additional means for indicating whether the pressure is correct or not is provided by means of the index, I (Fig. 2). This index can be moved and set at any desired position by turning the milled head, H, which actuates a crown wheel segment, Q, carried by the ring to which the arm, I, is attached. This index arm is coloured red, while the pointer, P, and the arrow-head at the lower end of the index arm are coloured black. If the pressure be exactly right, the red index arm is entirely covered by the black pointer; whereas, if the pressure be high or low, red is seen to the left or right of the pointer respectively. An attendant can therefore see from a distance of many yards whether the pressure has exactly the desired value, or is above or below it. The same milled head, H, works the arrangement for clamping the moving parts during transport;

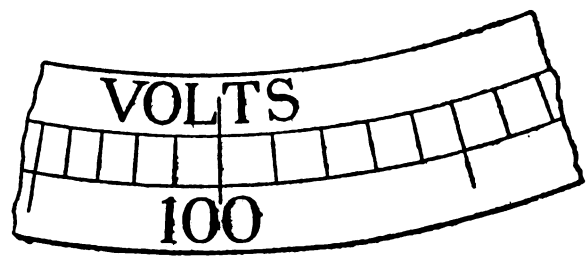

FIG. 4.

but this clamping device is so arranged that the moving parts cannot be clamped as long as the pointer is on any part of the graduated scale; hence there is no risk of the coil and pointer being accidentally clamped while the voltmeter is screwed up to the switchboard. To clamp the moving parts before removing the voltmeter, take out the two side screws that hold the voltmeter to the switchboard, and turn the instrument around the top screw until the pointer is deflected to the left of the graduated scale; then turn the milled head so as to bring the index up to the pointer, when the moving parts will be firmly clamped.

Lastly, the inside of the glass cover is coated with a layer of our transparent conducting varnish, described in the previous paper read to-night, and the instrument is thus screened from outside electrostatic action. Hence there is no fear of a change in the reading being produced by cleaning the glass—a very serious source of error, which is not uncommon with electromagnetic voltmeters in actual use in electric light central stations.

THE NORTHERN SOCIETY OF ELECTRICAL ENGINEERS.

We give below a report of the adjourned discussion on the paper read before this society by Mr. John H. Rider, entitled "Notes on Designing a System of Underground Electric Light Mains," and of the paper by Mr. S. V. Clirehugh on "The Various Systems of Underground Mains and Methods of Laying Same." The papers were given in our issue of March 16, and a report of the preliminary discussion in the *Electrical Engineer* of March 23.

Mr. Wooler: I myself should have liked to have heard some more definite advocacy of a particular system of mains and sound reasons given for such opinion, because it is patent that every class of mains have their advantages and disadvantages. For instance, bare copper conductors lay claim to economy in first cost. Well, this only applies where a large quantity of mains are required. One advantage which bare copper certainly does possess is the facility with which service connections can be made. What, however, I consider to be the most serious detriment to the use of bare copper is the space required to build the concrete culverts, and having to be frequently intersected with lengths of cables where headway cannot be obtained for the conduit, or underneath heavily-trafficked roadways where such a trench would not be calculated to sustain the weight unless strengthened to unwarrantable proportions, as demonstrated by Mr. Clirehugh with the samples on view. Mention has been made of fires and explosions. Well, in the very early stages of most new supply works it is their experience to have one or two disturbances of this kind. They answer the useful purpose of forcibly removing any weakness which may have been overlooked during construction, and generally benefit the undertaking by reason of preventive measures being taken for the future. In the case of cables under

* Tests made from month to month of the sensibility of two of the latest form of the Weston voltmeter show also that the sensibility slowly increases. This arises, probably, from the permanent magnets having been too much weakened before these instruments were originally calibrated, so that the magnets have increased their strength with time. These two instruments now read 1·3 per cent. and 1·7 per cent. too high respectively, after allowing for the fact that the unit P.D. employed in the original calibration was the legal volt, and not the "Board of Trade" or "International" volt.

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the drawn-in system, all the injured ones would have to be pulled back to the next coupling-box on either side, renewed, jointed, and vulcanised, which would be a lengthy occupation, but if bare copper was concerned, the strip and porcelain insulators may be blackened, which, with cleaning, and a little adjustment, would soon be rectified. Both of the authors began their discourse asserting the importance of the question of mains bearing upon the designing of a central station; then they go on to tell you that bare copper conductors, although admissible for low tension, are unsuitable for high tension on account of induction effects: therefore choice is limited, and I contend that the primary feature is to decide upon the system to be adopted. If high tension is selected, then small mains with high insulation resistance, or concentric cables, as explained to you, will be required, and a preference for low tension means very heavy expenditure for thicker mains, in addition to the by no means ignorable item which becomes due for royalty upon finding yourselves compelled to distribute upon the three or five wire system to keep up the E.M.F. in congested quarters. Of course, with high tension, only a comparative fraction of copper could be wanted for conductors, but expenditure in the direction of transformers would absorb a portion of its equivalent in cost.

Mr. Corlett: There is one remark I should like to make about bare copper strip. Since the last meeting I have obtained some reliable figures as to results we get in actual practice, and I find at the station in Brighton, or rather in Hove, that in wet weather the average insulation resistance runs from ·35 to ·5 megohms per mile, and in dry weather we get from 2 to 3 megohms. I think this is a very satisfactory result. I find from figures I have had from Kensington station (the oldest three-wire system distributing on bare copper strip) the total cost for laying the system for Kensington amounted to £56,000. Of this amount upwards of £30,000 was spent in 1890, and nearly the whole of the remaining sum was spent in 1891. The following are the figures for maintenance, and included in this is all repairs to surface boxes caused by wearing away of cement, trifling modifications in pavement, resetting of boxes caused by reflagging, etc.: in 1888 the maintenance bill was £24; in 1889, £40; in 1890, £56; in 1891, £98; in 1892, £364; and in 1893, £280—making a total altogether of £862 for the six years. If we take it that the whole was spent in four years, or base our maintenance cost as this sum divided by four instead of by six, and take the capital outlay as £50,000, we get a sum of £215 a year in a capital outlay of £50,000, which works out ·43 per cent. per annum; and as local authorities can generally borrow money at 3½ per cent., the total cost to the town of the upkeep of these mains would only amount to 4 per cent.

Mr. T. Callender: Previous speakers seem to treat vulcanised rubber as the only material used for underground mains. This is hardly the fact, for when we look into details it is astonishing how little rubber actually is used and for distributing mains, especially to what an extent it is being superseded. I find that up to last Saturday there are 82 stations in the United Kingdom under the Electric Lighting Acts, which are either in actual work supplying electricity for lighting, or for whose mains definite contracts have been given out. These 82 stations have their mains insulated—39 exclusively by materials other than rubber; six are strip systems with bitumen cables; five have their network of cables other than rubber, but part of their high-pressure feeders are of rubber; 19 are rubber insulated throughout; seven are strip systems with rubber cables; and six are common to all, the cables being insulated by rubber and bitumen or of the lead-sheathed type. In lead-sheathed cables the mains for the 11 following stations were secured by Messrs. Siemens: Bradford, Kingston-on-Thames, Dewsbury, Bristol, Hampstead, Derby, Bolton, Halifax, Londonderry, part of St. Pancras, and Southport; whilst Salford, Exeter, Taunton, Yarmouth, and Harrogate are in the hands of other makers of lead-sheathed cables. The cables for Brighton, the Crystal Palace District, and for the City of London have been made partly by my company, partly by others. I now take the liberty of referring to the work of my company. In 15 stations the mains are laid by us throughout, part are with lead-sheathed cables, but the majority consist of vulcanised bitumen cables. The entire distribution networks have been laid by us at Oxford, Sheffield, Hanley, Coatbridge, and Huddersfield. We have laid our cables, in conjunction with more or less bare copper strip and culvert, at Pontypool, Northampton, Southampton, Aberdeen, Belfast, St. James's and Pall Mall District. Messrs. Johnson and Phillips are responsible for two stations—viz., Rochester and Keswick. Norwich and Preston are on bare strip systems of special designs. Having thus given a rough analysis of the mains actually in use or under construction, what inference may we draw? It certainly does not tend to show that rubber is the chief insulating material. Where it is in use it is almost entirely in connection with alternating-current work, and it appears to me that the future in this division of electrical distribution lies largely with lead-sheathed and armoured cables. The simplicity of laying has much to commend this type of main. I believe that the position which rubber still holds for high-pressure work is seriously menaced, especially for concentric cables, by the type of lead-sheathed cable now being made by Messrs. Siemens, my company, and other firms. I claim that among the systems which have come here to stay, which have been used in the past and will be in the future, are those identified with my company's name. In regard to bare strip, I agree with much Mr. Corlett has said. When the sections of conductor are heavy culvert and strip can be laid cheaper than cables, but heavy sections are required almost exclusively in busy streets, and such streets have an unfortunate knack of being encumbered with pipes and cellars. If you move these, the expense is so heavy that your saving in first cost vanishes, and the usual plan of putting in part strip and part cable is never quite satisfactory. Unlike most cable-makers, I have laid a good deal of culvert, and I know exactly its weak points. The only town with which I am acquainted thoroughly suitable for culverts is Dundee—the station here is on a hill and the lighting area close to the seaside; but unfortunately towns with such natural advantages for draining one's culverts are not often found, and I cannot consider strip and culvert as universally applicable or advantageous.

Mr. E. H. Nisbett: I should not have occupied the time of the meeting to-night but that I thought some account of our experiences in the City of London would be of interest to members. Mr. Rider does not seem to me to have made it quite clear whether in speaking of "feeders," he intended to include both high and low tension mains. If low-tension mains are referred to I am quite in accord with his suggestion that a "built in" system should be used for the distributors and a "draw in" system for the feeders, as in this case the cost of the conduits is a relatively small item, but for high-tension work the conduits may cost actually more than the cable itself. To illustrate what I mean, suppose we take the case of a feeder having ultimately to transmit, say, 200 kilowatts, and it is determined to put down for immediate requirements only one-third of the total quantity of copper. In the case of a three-wire low-tension distribution we might then have to at once put down one-third of one square inch of copper, say, 0·33 square inch; a triple concentric cable of this section would cost about £1,500 per mile, and a conduit to contain it, with two spare "ways," would cost £350 per mile, making an immediate outlay of £1,850 (neglecting trench work), and an ultimate expenditure of £4,850 per mile for the complete feeder. Against this an armoured cable of 0·33 square inch section would cost £1,600 per mile, showing a lower initial expenditure, but the ultimate cost would be £4,800, and £400 for second and third trenchings, making a total of £5,200 per mile, or more than the "draw in" system. Now in the case of high-tension work it is different. The same feeder working at 2,000 volts will be 0·1 square inch section. A cable of one-third of this section will cost £155 per mile, and the culvert to contain it £310, bringing the total immediate outlay to £465, and the ultimate outlay to £775 per mile. Now, for £465 per mile one can purchase an armoured cable of ·1 square inch section area, and so at once put down the whole of the copper estimated to be required. Mr. Rider mentions the distance apart of feeding points as being not more than 250 yards if the distributing mains are to be kept of a reasonable size. I think this is putting the feeding points very close together; conductors having a sectional area of 0·1 square inch will, if on three-wire system, provide for five 8-c.p. lamps per yard of frontage alight simultaneously with a drop of 1½ per cent. This, it appears to me, is a heavy demand for a provincial town. I may mention that in the City of London we have provided for a demand which averages out at 4·5 8-c.p. lamps per yard of frontage. I think it is a pity that Mr. Rider, after having so carefully pointed out the importance of avoiding self-induction for alternate-current work, should have gone back on that by adopting a type of cable in which the self-induction is quite appreciable. I have made some experiments in the City, from the results of which I am enabled to state that the impedance drop in the type and size of cable that Mr. Rider is using is about 10 per cent. over the ohmic drop at 200 volts and 125 amperes at 100 volts, and the loss in the lead and iron sheathing about 50 watts per mile—not a large amount perhaps, but certainly worth taking into consideration. I must take exception to Mr. Clirehugh's statement that indiarubber cables "stand at the top from a scientific point of view." What is the scientific point of view of a perfect cable? Is it great durability, great dielectric resistance to pressure, high insulation, easy jointing, and cheapness? If so, I do not think that indiarubber does stand at the top. Such a cable as that manufactured by the British Insulated Wire Company, and used by us for all our work in the City of London, at least on some of these points is far ahead of indiarubber. The rubber advocates object that there may be pinholes in the lead, but a hole is just as likely to occur in the rubber during manufacture, and much more likely to develop afterwards. I have here a sample of a cable which has been working only two years. When it was laid down in the City the indiarubber was apparently perfect; it has lately been examined, and several lengths have been found in which the rubber is very badly cracked and unfit for further use.

Mr. J. B. Atherton: I was only saying to-day, in talking over some matters of this kind, I think it a very great mistake that more was not said to elucidate the difficulties surrounding questions of this kind than seem to be the inclination. It would be much better if the meetings tended to bring out what was best rather than crying down what one another were doing.

Mr. L. Andrew: I should like to have the opportunity of saying, with reference to my statement at the last meeting, that vulcanised rubber cable had only been used for 10 or 12 years. I was referring to electric lighting cables. Neither of the papers had reference to telegraph and other kinds of cables.

Mr. G. E. Preece (vice-president): Having been personally alluded to at our last meeting, it was my intention to have offered some remarks at the present meeting, but being unfortunately confined to my room by the doctor's orders, I cannot be present, but I have written down some few observations with regard to the papers themselves and their subject-matter, which I trust may prove acceptable to the meeting. Roughly speaking, the ground covered by the two papers consist of two points: (1) the conduit; (2) the insulated cable or conductor. Amongst the various classes of conduit described, no mention was made of that form introduced by the International Subway Company, and lately entirely used

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in Portsmouth for the town-lighting. It has also been used in other places, and largely in the United States. It figures up much cheaper than ordinary piping, and it has one very great advantage, that special facilities are provided for jointing and leading off from the mains to trenches or consumers' premises. As regards conduits for insulated conductors, the iron pipe and the drawing-in system has survived a usage of about 40 years, and is likely to last as long as it is necessary to place wires underground. One advantage of the iron-pipe system which has not been mentioned is that owing to the lengths of pipe used, and the excellence of the jointing, pipes do not give way owing to the inequality or subsidence of the ground, and the cables are not prevented from being drawn out, as has occurred in many of the built-up drawing-in systems. Lead piping has been frequently used, either pressed on hot, or pipes drawn down after the cable had been drawn in; but it has only been of late years that thorough attention has been paid to the internal insulation by a thorough dessication of the core before being soaked in the insulating material. There is no doubt but that in this form of cable we have now arrived at a very high pitch of perfection, and we are indebted to Mr. Clirehugh for an excellent description of the manufacture of paper insulation at the British Insulated Wire Company's works at Prescot, but I cannot help thinking that whilst such important improvements have been made with the core itself, no improvement has been made with the lead covering, which is practically the vital point in this form of cable. Indeed, I am inclined to think that from what I have seen and from information obtained, that the quality and durability of the lead used at the present time is not so good as that employed in the past. The question of maintenance and durability of this type of cable is essentially the question of the quality and durability of the lead and the excellence of its absolute perfect covering, for in that lies the strength and weakness of the cable as an insulated conductor, and, judging from my knowledge and experience of the material, and also by past experience, I am inclined to think that when it becomes a search for the "survival of the fittest," the lead-covered cable will not be there to answer. Since electric lighting has commenced vulcanised indiarubber has been used, and is being used at the present moment in increased quantities. Of its utility and especial adaptability to the work we have every proof, and of its durability every year gives additional evidence. There are cases where vulcanised rubber has not done good service, but this has been due to an inferior quality having been employed. As regards durability of vulcanised rubber, I show two samples of aerial cable sent us by Mr. Higgins, of the Exchange Telegraph Company. These were suspended in the air in November, 1873; they were taken down in 1893—20 years (nearly) after—on account of the house to which they were attached coming down, and not on account of any fault in the cables. The samples and letter are sufficiently explanatory. So far as efficiency and durability are concerned there can be no question but that vulcanised rubber has an excellent record, but some objections are made to it on account of its high insulation—unnecessarily high—and its expense. Some remarks have been made on the question of jointing vulcanised cores. There is really no difficulty about this, but for absolute perfection in a joint none but skilled workmen should be employed. I quite agree with Mr. Rider where he says in his paper, "I venture to think that a combined system of drawn-in for the feeders and built-in for the distributing mains offers a number of advantages." This plan was adopted with great success at Morecambe, and would be applicable to many cases. Gas explosions have been very frequent, but they are not so bad now as they used to be in the past, when the gas companies calculated on a loss of 25 per cent. through leakage at the joints of their pipes. At the present time the leakage in a good gas system is reduced to about 5 per cent. Gas is bound to get by filtration into electric pipes and conduits, and is sure to accumulate in the boxes. It is at this point ventilation should be adopted; a small pipe from the top of the box carried under the pavement and up the side of a house would prevent at once any gas from accumulating. Mr. Rider refers to telephone induction in his paper. The only way to efficiently prevent this on alternate-current working circuits is to employ no other form of cable but concentric, not only for mains, but for distribution.

Mr. Rider, in reply, said: I am sure that both Mr. Clirehugh and myself may feel satisfied that our papers have met with such useful discussion, though I am afraid that rubber held the day at our last meeting, and the points I raised hardly came in for discussion at all. My chief point was using "drawing-in" system for feeders and armoured system for distributors. Mr. Mountain and several others agree with that. Mr. Nisbett does not, and points out that an armoured feeder can be put down more cheaply. The Board of Trade have limited us to 100 h.p. for our transforming centres with the result that a cable for 200 kilowatts is out of the question, and as I should only put down a feeder for one feeding centre the advantage of an armoured system is not so apparent. My great point is "drawn-in" system for feeders. Where you have to go to distant districts you have to put an entirely new feeder down, and that feeder has often to go through the district already lighted. Bristol had just started when an outlying district wished to be supplied, and there was a terrible hubbub because they could not tap on to their present mains. There was a fine row about it, and electric lighting cannot afford to make any subject for heavy discussion in that way. You want to do it so that shopkeepers are not put to any inconvenience. If you have the pavement up in front of a main shop several times the shopkeeper will look at you in anything but a friendly spirit. Mr. Mountain spoke of splitting up a network instead of jointing the whole into one large network. In big towns, if a fault occurs on the other side of a town in the same network the whole system is jeopardised. In splitting up your network you there have the advantage of a breakdown in one part not affecting any other. Mr. Mountain says, with reference to the cables we are adopting in Bolton, that he did not know how three cables would be distinguished. I have a sample here, from which you will see that the distinguishing is very easy. We have three wires coming together in one sheath, the middle cable is lapped with jute strand, the other with jute strand and one string, and the other (the third) with a number of strings laid on over the jute the other way, so that on opening the cables you have no trouble in distinguishing. Mr. Mountain further spoke with regard to what he thought was a hollow in the centre. From the sample you will see that there is no hollow, and therefore no chance of moisture coming in. With regard to Mr. Clirehugh's table, he gives the cost of excavations at 5s. per yard. Mr. Cowan said it could be done for 1s. 2d. I can corroborate that. In Bolton we can supply and lay a 3in. pipe at 2s. 9d., and putting down 1s. 8d., the cost of pipe leaves only 1s. 1d. for the excavations, and at that the gas department can make a profit. I am sorry Mr. Clirehugh dismissed the armoured systems in one paragraph. I think there is a great future for them. I was also sorry that Mr. Clirehugh did not mention Callender's solid bitumen system, as that is one that should have a great future before it, at any rate for direct-current work. Lead-covered cables are all right if the lead is put properly on, and you should go to a maker who will put it on properly, so that there is no dross in it. If it is properly put on cold you have it without fear of pinholes. Mr. Clirehugh does not agree with me in regard to "drawn-in" feeders. Mr. Bourne and Mr. Nisbett both refer to the possibility of a drop owing to the three cables not being exactly central. To get rid of induction entirely, the three wires must be exactly central. I do not think that Mr. Nisbett can have tried a cable as we are going to use it, as none have been made. I agree with the speakers as to Crompton's bare copper. If you use proper insulators you can get rid of leakage, but if you put on saddle pieces you are bound to get leakage. It is not a point at all looked after as it ought to be in bare copper systems. They cannot be adulterated. The manufacturer cannot put into them any oxide of zinc, size, or rubber substitute. But with rubber cables he never knows within 20 per cent. how much adulterant it contains. I am sorry that Mr. Clirehugh withdrew his remarks about the difficulty of vulcanising joints. There is undoubtedly great difficulty in securing a good joint by this method, so much so that I may mention that some time ago we bought a considerable quantity of indiarubber-covered cable from a well-known manufacturer, but our men were quite unable to make good joints with the jointing material sent with the cable, and we were therefore obliged to purchase elsewhere. As regards flexibility, we lately tested a piece of 0·3 square inch triple concentric paper cable of 1½in. diameter, bending it to a 30in. radius and straightening it again without damaging it. It then successfully withstood a pressure of 4,500 volts, although only designed to work at 200 volts. A piece of rubber cable sold to the City Company for low-tension work broke down under the same pressure. Mr. Clirehugh states that under certain circumstances it is possible to draw 80 to 100 yards of cable in one length. In the City we have drawn as much as 185 yards of cable at one time, the length weighing two tons. Mr. Mountain at the last meeting said that paper-insulated cables were not suitable for high-tension work. Now, if they are suitable for anything at all, they are certainly suitable for use with high pressures. Mr. Wilkinson is now putting down paper cable at Southport, and he has lately been testing them to 20,000 volts without any sign of a breakdown—the thickness of the dielectric being only $\frac{1}{10}$in. The cables supplied to us in the City of London, and having to work at 2,000 volts, are tested after being laid and jointed to 10,000 volts.

Mr. S. V. Clirehugh, in reply, said: The main feature has been the discussion as to the difficulty of vulcanising joints in indiarubber cables, and there has been a certain amount of disagreement on the subject even among manufacturers of rubber cables. They have all stated that the difficulties of vulcanising have been over-rated, but it is admitted that it is desirable, nay, necessary, to send the jointers to the manufacturers to be taught to vulcanise properly, with the result that these men upon whom you have no hold are taught a trade at your expense, and afterwards, of course, demand very high wages. I believe the London supply companies are paying vulcanisers 10d. and 1s. per hour, and they are difficult to procure at that. Mr. Mountain has stated that he considers fibrous cable may be good for low tension, but hardly for high. He is, I think, under some misapprehension here, as fibrous cables have been used very extensively for the highest known pressures, and have only comparatively recently come into use for low tension. Plain lead-covered cables should certainly not be laid direct in the ground, but should be either drawn into iron pipes or protected by armour. With regard to Mr. Bourne's remarks, no doubt it would be possible to get sufficient insulation resistance with a less radial thickness of paper. It is, however, increased in order to get the mechanical strength required. With reference to Mr. Cowan's remarks *re* the cost of laying 3in. cast-iron piping, I had intended to convey the information that the price of 5s. per yard included the cost of the pipes, opening the ground and making good, temporarily, drawing in the cables, and including the Vestry charges; also joint boxes at the rate of 12 per mile. There was, however, a mistake in the table which I had not noticed. Mr. Nisbett says that I have damned lead-covered cables with faint praise, and he seems to be under the impression that my paper was intended to advocate the sole use of lead-covered cables. This was by no means the case, as, though I have great faith in them, they have not yet taken the place of rubber.

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THE
ELECTRICAL ENGINEER.

Published every Friday.
Price Threepence; Post Free, Threepence Halfpenny.
Editorial and Publishing Offices:
139-140, SALISBURY COURT, FLEET STREET,
LONDON, E.C.

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COMPANIES' REPORTS.

The period has almost arrived when the real position of electric lighting enterprises can be ascertained. There ought to be a large audience next Thursday at the meeting of the Institution to hear Mr. Crompton's paper on the "Cost of Electrical Energy." We have always agreed with those members who desire to obtain a copy of an interesting paper, say, a day before the reading, so that they may be in a position to adequately discuss it. Perhaps we might venture to suggest the sending of a post-card to the ever courteous secretary by those who desire to thus see a copy in advance, and, no doubt, when papers are received in good time, and are in type, the Council would permit the sending of copies to possible debaters. As it is, a few men, more or less intimately connected with the Council or the author, have an advantage: and it may be due to this that the discussions are too often restricted to men around the table. It is almost impossible to keep from general statements when speaking to a paper only heard rapidly read, or read in abstract. The value of discussion is not in the generalities, but in the specialities, and the closer a speaker keeps to the text of the paper the more valuable his speech. Of course we cannot comment upon a paper unread, nor have we any desire so to do, but the publication elsewhere in our columns of two reports—one from a large company, the other from a local authority—raises questions which may or may not be discussed by Mr. Crompton. For example, sufficient money has been spent on central stations for an analysis to be made so as to compare the cost per unit which a supply company pays with that which a local authority pays. Another analysis much required is the annual percentage, so to speak, of capital taken up in progression. Let us explain what we mean. A very large amount of initial outlay—that is, capital expenditure—as we all know, is usually laid down in mains as a preparation for extension. Suppose, now, someone with a little time to spare, and who had the information which, unfortunately, journalists cannot well get, would calculate the capital expenditure required for mains for the distribution at the end of, say, three months' working. Take that as the necessary expenditure. During the succeeding twelve months a certain number of lamps are added, and the supply of energy is increased. This increase would account for another part of the capital expenditure in mains. Gradually, the full load that the mains will carry is obtained. We think that a careful analysis of different stations would show how fast or how slowly the initial capital is absorbed in productive capital. If this could be done, and the result was, as we fancy it would be, satisfactory, many more local authorities would be in favour of immediate action rather than of delay. Take the Metropolitan report. It shows a capital expenditure of practically £600,000, and this brings in a gross return of £69,000, or a net return of close on £16,000. The shareholders are to get five shillings per £10 share. The promises of the chairman of this company have hardly been fulfilled. What, however, we want

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to know is the amount of capital which is really earning this £16,000, and the amount of what we call unproductive capital. This in many cases will also enable us to tell another tale. Capital may have been wasted, and in some cases, no matter how soon full load is obtained, the earning power of that part of the capital utilised productively will be insufficient to pay a dividend on itself and that part wasted. If we were much interested in the Metropolitan as shareholders, we should want to know a little more about some of the items charged to capital. We think the balance-sheet sails very closely to the illegal line, that various items are placed to capital account which ought not to be there. The accounts of the St. Pancras Vestry will be closely examined by all local authorities, and here is shown a net revenue of £6,200 obtained with a capital expenditure of £100,000. Comparing this with the Metropolitan, the St. Pancras Vestry would show at the above rate a net return of £37,400, instead of the £16,000 shown in the other accounts. The comparison, if we cared to continue it, would be immensely more in favour of St. Pancras than the Metropolitan—but such comparisons are odious because the data are doubtful. We know not how much of the Metropolitan expenditure is as yet unproductive. It may be that the St. Pancras expenditure is all productive, and the other mostly unproductive. But these things want closely watching.

WINDY.

Last week we made use of the fact that a meeting of the Tramways Institute was then being held in Manchester as a peg whereon to hold a brief dissertation upon tramway matters in general, and the prospects or possibilities of the overhead conductor or trolley-wire system in particular. The publication elsewhere in this issue of a paper brought before the institute at this meeting—viz., that contributed by M. Victor Popp, of Paris, under the title of "Mechanical Tramway Traction: Compressed Air or Electricity"—gives a further opportunity for criticism not only upon the paper itself and the views expressed therein, but also with reference to the institute, and its true scope.

It is certainly a fact that they manage some things at least better in France than here, and the quality of work done by the author of the above paper in erecting power distribution systems throughout certain parts of Paris has doubtless been such as might with advantage find imitators on this side of the Channel. It is, however, becoming a serious question with us whether the countrymen of Jules Verne do not regard as substantial facts the fantastic results of this great novelist's imagination. Certainly, we cannot otherwise very easily explain the large number of extraordinary French engineering enterprises lately "seen in the flesh"—solid, tangible facts, such as the Heilmann locomotive, the electric locomotives said to be in process of manufacture by the Paris, Lyons, and Mediterranean Railway Company, and designed to run the main-line expresses by means of accumulators, and, lastly, the compressed-air tramcar system advocated by M. Popp, examples of which (in its unregenerate form) are to be seen in the neighbourhood of Paris.

In our ignorance and insular prejudice we had somehow got the idea that compressed air—as a motive power even upon tramways, where light loads are the rule—was, to put it mildly, "played out" some time ago. The difficulties involved in combating the variations of temperature which follow upon the compression and expansion of air have been practically insuperable, so long as the element of economy remains the most important consideration. Then, again, the questions of storage, the weight and size of suitable reservoirs, are matters not settled quite so easily or satisfactorily as might be thought possible. All these disadvantages are, we must confess, frankly acknowledged by M. Popp, who claims, however, that they are largely, if not wholly, avoided by the newer forms and appliances which he advocates for the use of compressed air on tramways.

It is not our main object here to point out the objections which might be raised to the employment of this system; it has many advantages of an important character. Each car is self-contained, and no obstruction is created in or on the streets and roads. The sole test or standard by which compressed air may be compared with electricity as a suitable motive power for tramways is the question of expense—first cost and daily outgoing. Until more details are given, of a reliable nature, than are set forth in M. Popp's paper, we cannot very well attempt any decision of this point, or examination into the problem generally. We do, however, wish to protest very strongly against the assumptions and statements made by M. Popp in drawing up his indictment of electric traction.

Everyone, of course, is fully aware of the objections to the use of electric accumulator cars—perhaps none more so than those who have been unfortunate enough to try them in actual service. This type of electric working stands pretty much on a level with compressed air itself: though we feel somewhat generous in admitting this, taking, for instance, the figures given by M. Popp with regard to the weight of cars. An accumulator car weighing, without passengers, seven and a half tons might have existed years ago, but we have progressed a little further than that now, though so long as lead remains the metallic base of accumulators the weight will always be prohibitive. It is when M. Popp attempts to criticise the overhead conductor system that he fails most miserably; indeed, it is hardly possible to take his arguments seriously. The best proof of their value lies in the fact that Germany, Italy, and even France are all erecting overhead wires for the operation of tramways in some of the principal streets in the principal towns and cities; and M. Popp's naïve confession that the trolley system is used in America "for want of a better," puts the whole question in a nutshell. There is no better, taking it all round; and hence its increasing adoption. The wires, M. Popp says, are in the way of fire-escapes and festival cars! Let the fire-escapes be turned into horizontal built-up fire-ladders on wheels,

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that can be whipped round by horses to a fire in half the time that an unwieldy perpendicular staircase takes for two or three men to push along. As for the festival cars, they will have to take trips into the country outside the towns: to claim that they shall interfere with the everyday efficient and economical working of tramways can only be characterised as absurd.

Whilst criticism of this kind is made necessary, a tribute of praise may well be given to M. Popp and those who have collaborated with him in perfecting the details of this ingenious system which the paper describes and advocate. We do not think for a moment that it will ever come into extensive use, but that does not prevent appreciation of its development as herein set forth. The Tramways Institute, moreover, will serve a most useful purpose if it obtains other papers from well-known engineers for perusal at the quarterly meetings; up to a little while ago the quality of communications brought forward was not, perhaps, of such high quality as the potential importance of this institute would appear to demand, but we are glad to note a steady improvement for some time past: and if the officials of the institute will only remember how great a field lies before them on the growing introduction of mechanical powers upon our tramways, they can raise the position and prospects of the institute very materially. The papers to be read should come from engineers and officials in the front rank in order to gain the attention of the world at large, and they should be reserved for the institute, and not consist merely of rehashed articles from the technical Press. With these points in mind, and a continuation of the same energy that now characterises the institute, there should be a prosperous and important future for this organisation, whether its members are connected with lines owned and operated by companies or by municipalities.

THE ELECTRICAL STUDENT'S A B C.

A is the Amp. that went into the Arc.
B is the Brush, sometimes seen with a spark.
C is the Copper, most handy for mains.
D is the Dynamo driven without reins.
E is the Science we study and pass in.
F is the Field, with more iron than grass in.
G is the Galvo., which "shorts" can foretell.
H Hysteresis, heats iron like —— (anything).
I is Induction, much blessed and cursed, too.
J is the Joule, set in carbon and cu.
K is the Kathode, who lives in a bath.
L is the Line cut by wires in its path.
M is the motor, which torques as it works.
N Non-conductor, which carrying shirks.
O is the Ohm found in wire as in brick.
P is the Pole which to iron wood stick.
Q the Quickbreak on a high-voltage circ.
R the Rheostat, which 'eats when at work.
S is the Switch, like the ones used with trams.
T is the Telephone; earns many bad —— (words).
U is the Unit, at fourpence a blessing.
V is the Volt, who is always most pressing.
W the Watt; E.C., when you know it.
X the Xpense. House installers should blow it.
Y is the Yoke, which in magnets is grey.
And the
Z inc has connection with bells every day.

April, 12, 1894. J. H. C. B.

ON CERTAIN NEW PREFIXES PROPOSED FOR PHYSICAL UNIT MAGNITUDES.

BY EDWIN J. HOUSTON, PH.D., AND A. E. KENNELLY, F.R.A.S.

The increasing extent to which scientific unit magnitudes are being used in physical research has received a check by the inconvenient size of some of the fundamental C.G.S. units, particularly the dyne and the erg.

In order to lessen this inconvenience, we would propose the following additional prefixes, which we have found convenient in our own work.

For example, instead of writing "one thousand megergs" we would suggest the term "one begerg"; and, similarly, for the expression "one million megergs" the term "tregerg," and for a "billion megergs" a "quegerg," following the analogy presented by the words million, billion, trillion, and quadrillion.

Again, instead of writing "the one thousandth of a microfarad," we would suggest the use of the term "bicrofarad," and also the tricofarad as the millionth of a microfarad where necessary. The meaning of these suggested prefixes is, therefore, as follows:

Bega = 1,000 million, or a billion, or 10^9.
Trega = one million million, or a trillion, or 10^{12}.
Quega = 1,000 trillion, or a quadrillion, or 10^{15}.
Bicro = 1,000 millionth, or 10^{-9}.
Tricro = one trillionth, or 10^{-12}.

The following applications of these prefixes will suggest their advantages.

From 1 metre = 1· metre = 100· cms.,
and 1 mm. = 0·001 metre = 0·1 cm.,
and 1 micro-metre = 1· micron = 0·000,001 metre = 10^{-6} metre = 10^{-4} cm.,
1 bicro-metre = 1 bicron = 0·000,000,001 metre = 10^{-9} metre = 10^{-7} cm.,
1 tricro-metre = 1 tricron = 0·000,000,000,001 metre = 10^{-12} metre = 10^{-10} cm.

The micron is of the order of the length of a light wave in the ether, and is a fundamental unit of magnitude in microscopy.

The bicron is a magnitude which will be useful in dealing with the mean free path of gaseous molecules, according to the kinetic theory of gases.

The tricron is of the order of molecular dimensions, according to the estimate of Kelvin.

From 1 megadyne = 10^6 dynes = approximately the earth's gravitational force on one kilogramme of matter.

One begadyne = 10^9 dynes = roughly the earth's force on one ton of matter—*i.e.*, the weight of one ton.

One tregadyne = 10^{12} dynes = roughly the weight of 1,000 tons.

1 megarg = 10^6 ergs = 0·0737 foot-pound at Greenwich.
1 begerg = 10^9 ergs = 73·7 foot-pounds at Greenwich.
1 tregerg = 10^{12} ergs = 73,730 foot-pounds at Greenwich = 37 foot-tons approximately.

From 1 megohm = 10^6 ohms.
1 begohm = 10^9 ohms = 1,000 megohms.
1 tregohm = 10^{12} ohms = 1,000,000 megohms.
1 quegohm = 10^{15} ohms = 1,000 tregohms.

A begohm is about the insulation of one mile of well-insulated conductor.

A tregohm is about the resistance required to limit the deflection of a high-grade mirror galvanometer under one volt to one scale division of one millimetre at one metre range. Such a galvanometer might be called a tregohm galvanometer.

A quegohm is the limiting resistance with one volt and unit deflection of an extremely sensitive mirror galvanometer, which might be termed a quegohm galvanometer.

From 1 microfarad = 10^{-6} farad.
1 bicrofarad = 10^{-9} farad, or 1/1,000 microfarad.

The C.G.S. electromagnetic unity of capacity being 10^9 farads is consequently a begafarad. The use of these prefixes, therefore, assigns a convenient name to the C.G.S. unit of capacity, which would otherwise require a special denomination.

From 1 henry = 10^9 cms.
and 1 microhenry = 10^3 cms.
1 bicrohenry = 1 cm.

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CONTINUOUS-CURRENT TRANSFORMERS IN SUB-STATIONS.*

Several alterations are being made by the Paris Compressed Air Company in the sub-stations which they established for the supply of electrical energy in the district over which the company have powers. Among these is the use of continuous-current transformers in place of certain sets of batteries which have hitherto been used for the total service. The primary circuit of this transformer, connected in circuit with the primaries of the other stations, receives electrical energy at high tension from the Saint-Fargeau station or from that in the Boulevard Richard Lenoir. It works as a motor, and actuates a generating dynamo giving current at 120 volts. The same arrangements have been adopted in all the sub-stations, of which there are 23 in Paris. We will now proceed to refer to the sub-station in the Bazar of the Hotel de Ville.

This sub-station contains two batteries of 67 accumulators, of the type made by the Société pour le Travail Electrique des Metaux, of a capacity of 2,500 ampere-hours, and two continuous-current transformers. The accumulators serve to keep the pressure constant, and to replace the transformers in case of necessity. The transformers are respectively of 70 kilowatts and 33 kilowatts capacity; they are formed of two Thury dynamos having six forged-iron inductor poles, and are coupled together by a Raffard coupling. A switchboard is provided for each dynamo. The motor is excited in series and the generating dynamo in shunt. The current in the primary circuit of the 33-kilowatt transformer can reach 275 amperes at 175 volts, and 300 amperes at 110 to 120 volts at a speed of 550 revolutions. The figures for the 70-kilowatt transformer are 340 volts and 275 amperes in the primary circuit, and 110 to 120 volts and 640 amperes in the secondary circuit at a speed of 450 revolutions.

Our illustrations, Figs. 1 and 2, show the arrangements of the distributing switchboards. At P and P', Fig. 1, is shown the two wires of the high-tension circuit. The current passes through an ammeter, A, a switch, C, the armature, H, of the motor, M, and the inductor, I; a portion passes along the cable, X, into a graduating rheostat, R. The circuit is afterwards closed by a switch, C^1, which is connected to the leading-out wire, P'. Several other appliances are placed in shunt. V is an automatic safety appliance, which normally should be open; when an accident takes place, or when the difference of potential rises above the normal, a fine wire solenoid attracts a soft-iron lever, which short-circuits the line. B is a voltmeter with a fusible cut-out, E; and D is a switch which allows of the sub-station being short-circuited at the moment of stoppage.

The low-tension switchboard, Fig. 2, carries an ammeter, A, a voltmeter, B, an automatic switch, C, a switch, D, and fusible cut-outs, E and E^1. A hand rheostat, R, permits of the resistance of the excitation in shunt being varied at will. A third and general switchboard allows of the station being short-circuited in case of accident, or of successively isolating each of the transformers, or of substituting equivalent resistances for them.

The various operations in a sub station of this kind are as follow: (1) the starting of the transformers for a large demand by utilising, in case of necessity, the discharge of the accumulators to make up the total power to be distributed; (2) the stoppage of the transformers after the greatest demand; (3) the charging of a part of the accumulators and the discharging of the other portion of the cells.

To set the transformer in operation the safety appliance, V (Fig. 1), is opened, the switches, C and C^1, are put in the contact-pieces, and the rheostat, R, is at the bottom of the course, at Z—that is to say, out of circuit. The switch, D, is then opened. The general circuit of the motor is found to be closed, and the current passes through the ammeter, A, the plug C, the armature, H, and the cable, X. By varying the resistance, R, the motor, M, starts, and it is only necessary to regulate this resistance to impart the desired speed to the generator, G, as shown in Fig. 2. When the difference of potential has reached the normal the automatic switch is closed and the resistance, R, is regulated.

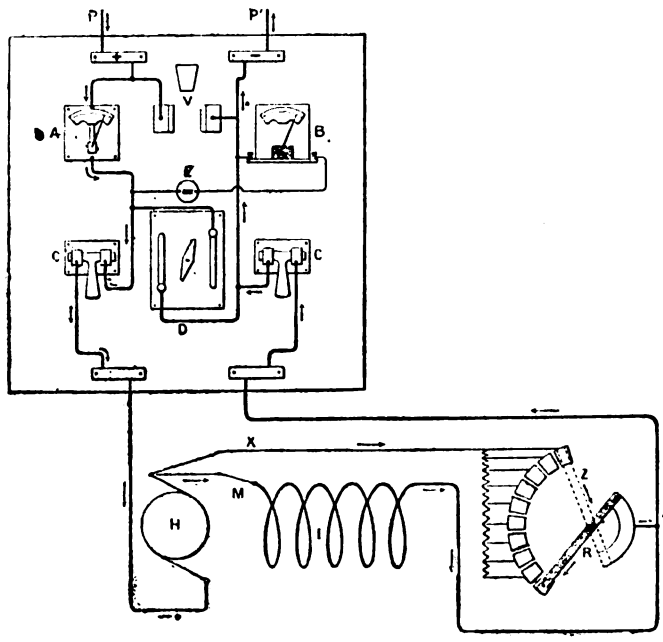

FIG. 1.

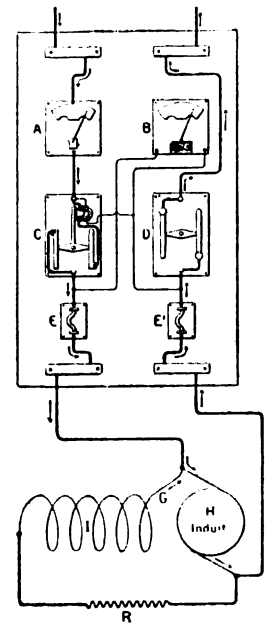

FIG. 2.

If at a given moment the power expended in the external circuit becomes greater than that produced by the transformer, one or two batteries are connected in quantity with the latter.

The stoppage of the transformer is commenced by diminishing the resistance, R (Fig. 1), of the motor, so as to reduce the speed of the latter. When the difference of potential falls to 0 on the distributing switchboard, Fig. 2, the switch, D, is opened, the switch, D, on the first switchboard is closed, and the switches C and C^1 are pulled back.

Each of the transformers is provided with automatic rheostats, with centrifugal force regulators allowing of the secondary difference of potential being maintained constant. It is claimed that the efficiency of the transformers at full load is 80 per cent.

* Abstracted from *L'Industrie Electrique*.

Hungary.—The town of Erlau is to be included in the telephonic system connecting Budapest and other Hungarian towns if a sufficient number of subscribers comes forward.

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A 5,000-H.P. WATER-POWER PLANT.

Considerable interest is being manifested in the United States in the new water-power plant of the Concord Land and Water Power Company at Sewall's Falls, on the Merrimack River, about three miles above Concord, N.H. It is believed, with the exception of the Niagara Falls power station in course of construction, that this is the largest water-power plant in existence that is in practical operation. The water was turned on and the plant started at the end of February.

Mr. A. C. Shaw, who describes the generating station and plant in the *Electrical Engineer* of New York, states that the first problem to be solved was the damming of the Merrimack River, and that the services of one of the best hydraulic engineers in the country were brought into requisition—the design for the dam being furnished by Mr. E. F. Smith, of Philadelphia, engineer and superintendent of Schuylkill and Tide Water Canal, and the details of construction carefully carried out by Mr. Daniel Ulrich, of Newark, N.J. The dam is of the crib construction filled in with broken stone, is 497ft. long, 67½ft. wide, and is 22ft. deep from the comb to the bottom of the foundations. The fall of the water from the comb of the dam to the bed of the river below is 14ft., and is gradual, the water being allowed to flow over three or four easy drops and slopes and pass away comparatively quietly on to the bed of the river. The canal is 1,300ft. long, 60ft. wide at the surface and 10ft. wide at the bottom, with an average depth of about 11ft. There are five openings, each provided with a gate 10ft. by 10ft., and the three centre gates are each fitted with an auxiliary gate 5ft. by 2ft. as it would be impossible to open the large gates when there is any considerable difference of level between the river and the canal. The canal runs the whole length of the power-house, its foundation wall forming one side, in which are set the immense penstocks which convey the water from the canal to the wheel cases. At the end of the canal, with one end tied into the power-house, is the waste-weir, fitted with removable flashboard, so that any level of water can be preserved in the canal.

The power-house, which has been designed for 2,000 h.p., is of substantial mill construction without any ornamentation, is 160ft. long, 45ft. wide, and 47ft. high from the foundation to the top of the roof. The foundation is composed of 10in. by 10in. ties, puddled into a hard pan bottom, with sheet piling at the sides. On top of the timbers is a layer of plank upon which rests the masonry. There are three longitudinal walls of masonry of separate heights and depths, tied together at every pulley pit. The canal wall, which is naturally not so deep as the others, owing to the difference in level of the canal and the tail race, is 6ft. 4in. wide at the bottom, has the front face vertical, is 2ft. 10in. thick at the top, and is 22½ft. high. The other two walls are 5ft. thick at the bottom, 3ft. at the top, and 26½ft. high. The canal wall is 6ft. 9in. higher than the other two walls, to protect the generator-room from possible inundation in time of flood. These walls are of solid granite and cement, and on them rests the brick walls of the generator-room, which are 20in. thick, and built with solid lime cement.

The wheel-room is 150ft. long by 15ft. 10in. wide and 15ft. high, and is designed to accommodate five pairs of 39in. horizontal turbines, four of which are now in position, of the Rodney Hunt type, manufactured specially for this work by the Rodney Hunt Machine Company, of Orange, Mass. Each pair of wheels is contained in a case 8½ft. in diameter by 11ft. long, and will develop 400 h.p., each wheel being designed for 200 h.p. Each case is connected to the canal by one 8½ft. ⅜in. steel penstock, passing through the centre wall, and ending with a cast-iron flange on the outside face of the canal wall, in the forebay. The water leaves the wheel case through a 48in. steel quarter turn, and passes through a steel draught tube 48in. in diameter, set at an angle of 40deg. from the vertical, and passes out horizontally into the tail race, the bottom end of the tube being bent for this purpose.

These tubes are at all times full of water, the water backing clear to the wheels, thus getting the full power of the entire fall without having the wheel submerged at the lowest depth, and enabling belt transmission to be used instead of the ordinary noisy gearing and shafting. The shaft, 6½in. in diameter and 29ft. long, extends through both wheels and both quarter turns, and is connected at one end by means of a coupling to the transmitter pulley, which is a heavy cast-iron flywheel, 11ft. 6in. diameter by 32in. face, revolving at 150 revolutions per minute. Each shaft is entirely separate from the others, making separate units, and each unit can be used separately, or combined by means of friction couplings on the floor above.

Each pulley runs in a boiler-plate, watertight belt-pan, which extends to the centre of the shaft, so that even should the wheel-room become flooded, there would be no damage to the belts, unless the water should rise higher than the shafting, a contingency extremely improbable, as ample pump capacity is provided to take care of any water leaking or percolating into the wheel-room. The power is transmitted by 32in. double oak-tanned waterproof belts.

The generator-room, which contains the generators and the shafting, is 150ft. long by 40ft. wide, and 15ft. high. The shafting, which makes 300 revolutions per minute, is of hammered iron, and is 5in. in diameter, set in solid masonry foundations, and equipped throughout with ring oiling bearings. The main receiving pulleys are 5ft. 9in. in diameter by 32in. face, and are supported on a quill, with special quill bearings, so that the waterwheels can be started up independently of the shafting. The pulleys are fastened to the shaft with taper sleeve arrangement, which obviates all necessity for key ways and set screws, and makes the shaft much more rigid. The rims of the large pulleys are 2in. thick, and the whole shafting, in fact, has been made extra heavy, forming in effect one large fly-wheel, the inertia of which is an important factor in the regulation of the plant. This device has never before been employed, and is original with Mr. Carpenter. Hill friction clutches are used throughout, by means of which any combination can be secured, the wheel at the one end of the power-house being capable of being used to trasmit power to a generator at the other end of the power-house if so desired. The generator-room contains at present seven Thomson-Houston 50-light arc light dynamos, and six 250-kilowatt triphase generators, the second plant to use the triphase current in the United States. These generators will furnish current for incandescent lights, power, heating, and cooking, all of which is at present being done from the company's circuits. The voltage of these triphase generators is 2,500, and the voltage at centre of distribution in Concord 2,200, where it is transformed to 110 volts, at which pressure it is used for the purposes enumerated above. The company is now operating about 5,000 incandescent lights, 250 arc lights, and 400 h.p. in motors. The electric apparatus has been manufactured by the General Electric Company, the generators and motors having been designed by Dr. Louis Bell.

MECHANICAL TRAMWAY TRACTION: COMPRESSED AIR OR ELECTRICITY.*

BY M. VICTOR POPP.

Electric Propulsion.

When an electric accumulator puts forth the energy that has been stored in it, this energy is already going through its fifth transformation—viz. :

1. Transformation of the initial heat into motive power. Transforming medium : the steam-engine.
2. Transformation of motive power into electricity. Transforming medium : the dynamo.
3. Transformation of electricity into chemical electrolytic work. Transforming medium : the electric accumulator during the charging process.
4. Transformation of the chemical electrolytic work into electricity. Transforming medium : the electric accumulator while discharging.
5. Transformation of this second generation of electricity into motive power, as in the case of an electric tramway. Transforming medium : the electric motor.

When the accumulator is used for lighting purposes, the chemical electrolytic work is transformed into heat and light by means of the outgoing currents. In this case, the lamps are the transforming medium. Should the accumulator be used for the electrolysis, the chemical electrolytic work is converted by the same

* Paper read before the meeting of the Tramways Institute at Manchester.

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intermediary into other work of the same kind. And, as a loss of energy is fatally consequent upon each transformation, we easily perceive what the final return must be in comparison with the expense of initial energy. This return is undoubtedly inferior to any obtained by other processes of mechanical propulsion for the same cost of initial energy. Experience and theory agree in this. The great dead-weight which a battery of accumulators of sufficient power and capacity adds to a car, the waste of time in recharging, the cost of renewing and forming plates, are so many inconveniences which it has been sought to avoid by the use of elevated or underground conductors along the entire length of line. In fact, propulsion by means of accumulators is incontestably much the most expensive of all methods. Low efficiency, extravagant cost of maintenance and renewal, are such acknowledged deficiencies as to put it beyond question that this method of mechanical traction can show at best but a trifling economy over animal traction. Consequently it is but little used. The Tramways Company and the General Omnibus Company of Paris, after careful investigation, have definitely refused to consider the use of accumulators.

Electric tramways, not on the accumulator system, are worked by means of elevated or underground conductors. Current is supplied to the cars by grooved wheels or brushes running along these conductors. The return of the current is generally effected through the rails. The successive transformations of initial energy are, in this case, only three, but to the losses occasioned by these transformations must be added those resulting from the resistance of the line and the imperfect insulation. We have also to consider the considerable cost of erecting the conductor, the metal itself, the poles, insulators, etc. It is true that these expenses are incurred only at installation, but the cost of maintenance of both elevated and underground systems are great, especially in the latter case. As the principal drawback to electric traction by overhead conductors lies in the cost of maintenance, we will give some details on that point. The wire carrying the current is always suspended above the middle of the track on which the cars run. Usually current is transmitted by a single wire suspended above each track, and the circuit is completed by the rails. In some cases, where owing to some special conditions of track the return of the current cannot advantageously be effected through the rails, a complete suspended circuit is established which requires two wires for each track, one transmitting the current to the motors and the other returning it to the central station. Experience shows the difficulty of establishing and maintaining connection with the conductor at the curves and switches. The poles, brackets, and interlacing wires are encumbrances and unsightly. Municipalities which regard the appearance of their streets refuse to allow their installation. These elevated wires, with their poles and other supports, are so great a nuisance and so unsightly that we are not astonished at their proscription from the thoroughfares of most European cities. For that very reason the capital of Austria has definitely rejected all systems of mechanical propulsion making use of elevated conductors At Brussels, where electric tramway lines with elevated conductors are now being established, very serious complaints have already been laid before the Town Council by the heads of the fire department, these wires being in the way of the fire ladders. The committee of the Brussels fêtes has protested against the establishment of these wires on account of interfering with the festival cars. Owing to similar complaints the Electric Tramways Company of Marseilles has been forced at a great cost to raise its wires and to change their position at certain points. In France, the Minister for Commerce and Industry has presented a Bill regulating the conditions under which electric conductors for transmission of power shall be established. The constant increase of electric installations for distribution of light or motive power, the dangers they present to the public safety, the disturbance they may occasion in the telegraph and telephone lines in their vicinity, cannot fail to attract the attention of the authorities. In future, permission to establish conductors on public thoroughfares, or in their immediate vicinity, will be limited by Government to such an extent as will ensure public safety and protection of the telegraph and telephone service. Every application made to public authorities for the establishment of electric conductors in France will have to be submitted to the consideration of the Government engineers before any concession is granted.

If in America the trolley system is in use it is only for want of a better. We hear that one of the most important tramway companies of New York is offering a prize of 50,000dol. to the lucky inventor who shall discover a better system of propulsion. In the meantime this company is establishing cable lines in preference to trolley wires. The high tension of the currents generally used for traction not only interferes with telegraph and telephone, but presents also a serious danger to public safety, as has been stated in the Bill proposed by the French Government. Recently, during a fire at Boston, where the elevated wires are so numerous and so entangled as to cover some streets with a metallic network, the firemen were not only prevented by wires from using their ladders, but a number of them received heavy shocks. For the twentieth time, at least, the insurance companies have demanded that all wires be buried.

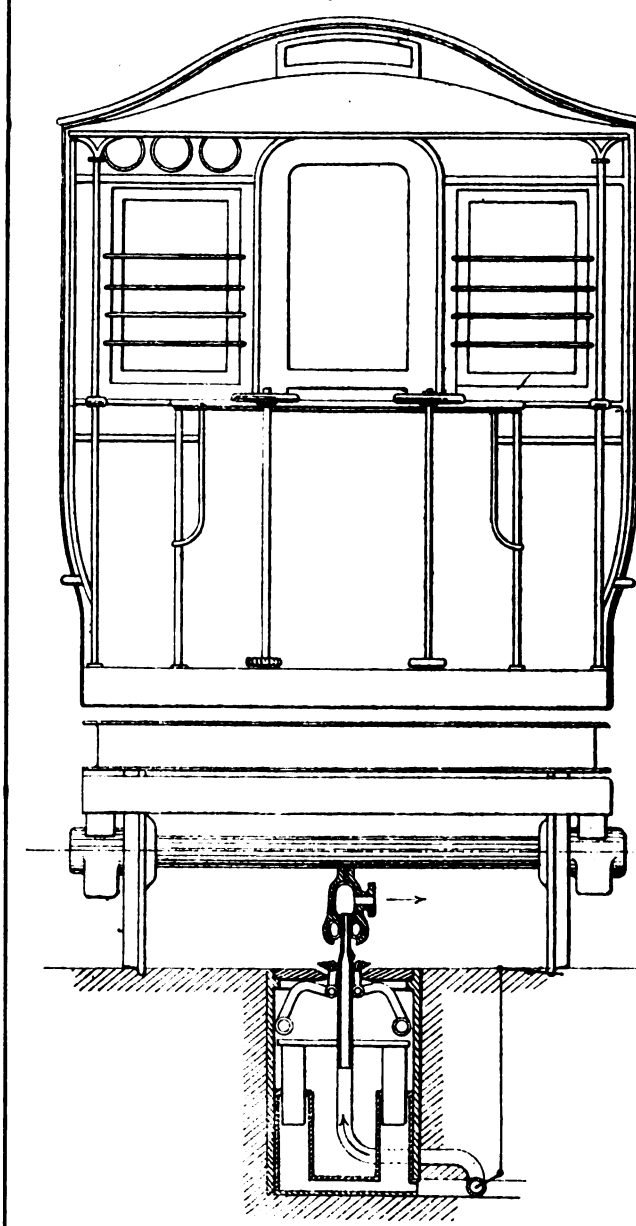
At first sight one might think electric propulsion by means of underground conductors preferable to the elevated system, but the trials already made show that, aside from the disturbances occasioned among other electric services, their establishment and maintenance costs a great deal more than the elevated wire or compressed air systems. That is why this system has been little used, and why it is not to be considered as a serious rival of the others we are describing.

Traction by Compressed Air.

It is impossible to better explain the position which compressed air as a motive power occupies than by quoting the report of Mr. Humblot, inspector-general of the Department of the Bridges and Roads of France. In effect, he says:

"Compressed air is not a source of power. It is in reality only a vehicle for the transmission of power in heat, which heat can retransform itself into power. In order to obtain from air an economical return, it is necessary to supply it with caloric at the moment of its utilisation by reheating, in order to compensate for the losses of every nature to which it has been subjected as a consequence of cooling after compression, in the tubes and reservoirs."

By employing compressed air in traction all the many advantages are secured which this agent has been demonstrated to possess in the mechanical applications which have heretofore been made. If there is anywhere a demand for an easily manageable motor, it is certainly for tramways. With compressed air, variations of speed are obtained with the greatest ease and without shock by the simple turning of a cock—stops are made almost instantaneously, as vehicles operated by this system naturally employ air brakes, the reliability of which is so well known.



Compressed air at high pressure is successfully employed on the Nantes tramways and upon the line from Paris to Nogent-sur-Marne. It has been recently adopted for two important lines in Paris. The Nogent compressed-air tramway carries nine reservoirs under the car. These are made of thick sheets of steel, and have a capacity of 682 gallons. The air is carried at a pressure of from 99·207lb. to 176lb. At this pressure, a total weight of from 374lb. to 660lb. of air is stored. Three of these nine reservoirs form an independent store, the high pressure of which is only used in cases where some excessive strain has to be met. The reheating of the compressed air when it leaves the reservoirs, and before it enters the motor cylinders through the pressure regulator, is effected by passing it through a receptable containing superheated water, and filled at the charging station. The amount of water carried is 44 gallons, and its temperature from 150deg. C. to 160deg. C. at starting. The weight of the Nogent car (seating 50) is 25,300lb.; including passengers, 31,900lb. Upon a single charge of air the car can run over 12 miles on an ordinary line. On the Nogent line, only 8¾ miles are made without re.

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charging with air and water on account of the constant and heavy grades. The average consumption of air between Maltournee and Vincennes, where the most severe grades are encountered, is about 35lb., while upon the section from Maltournee to Ville-Evrard, where, as in ordinary railway lines, the grades do not exceed 2 per cent., the consumption of air does not exceed 24lb. per mile. When the motor-cars tow a trail-car the consumption of air increases 30 to 35 per cent. With a loaded trail-car the weight of the train is about 48,400lb.

Traction by means of reservoirs containing compressed air is, in fact, the only system which has proved itself by long practical application, and demonstrated its real economy over animal traction. Its introduction into general use has been limited by the drawbacks which we now enumerate:

1. The first of these arises from the employment of air at the high pressure of from 45 to 80 atmospheres, of which only an average of eight to ten is made use of. This occasions a useless expense in compression.

2. The second consists in the necessity of carrying upon the car numerous reservoirs, constructed of thick sheets of metal and consequently very heavy, in order to afford reservoir space for a great quantity of air at high pressure.

The latter is a serious inconvenience, for not only is a great dead-weight constantly carried at a loss, increasing uselessly the expense of traction and being superfluous for adhesion, but the great weight of the vehicle sensibly wears upon the rails and occasions rapid deterioration of the road bed. In many cases the police regulations, as in Paris, limit the weight of tramway cars. In the case of the Nogent motor—which, without passengers, weighs 25,300lb.—the nine reservoirs, having a total capacity of 682 gallons, and constructed of steel plates 0·4724in. thick, form a supplementary load of 8,800lb., which must be kept in mind when considering the cost of traction and economy of operation. In this regard, the disadvantages of the Nogent motor are quite the same as those experienced in traction by electrical accumulators, the latter suffering equally from the necessity of having to constantly carry an enormous weight which it has so far been impossible to dispense with.

3. The car used with the Nogent system is not so constructed as to allow of the use of axles independent horizontally, so that it has been found necessary to draw the axles too closely together, in order to operate over even ordinary curves. This arrangement must inevitably destroy the stability of the car, and produce a see-saw motion, which not only militates against good running, but is extremely disagreeable to passengers.

4. In this same motor-car the two reciprocating motors are placed below the level of the car body and at the sides. Their movements in the same direction being successive and alternating, there results a continual rocking motion, which is even more damaging to the rails and disagreeable to the passengers than the see-saw motion above referred to.

5. The front platform is entirely occupied by apparatus. It is consequently useless for passengers.

6. As the car can only run in one direction, turntables become a necessity. This increases first cost and maintenance, complicates operation, and wastes time.

7. It is necessary for cars of the Nogent type to take in a supply of superheated water at the same time as the reservoirs are filled with compressed air. This double operation necessitates the feeding station being placed near a boiler, which would often be impossible in a city.

8. In this system, supplies of compressed air and hot water can only be taken in at the station; this, if the trip is sufficiently long, renders the construction of one or more special stations necessary along the line. Furthermore, this supplying of the reservoirs requires considerable time, and delays the service.

Objections Nos. 1, 2, 5, 6, 7, 8 above mentioned are found as well in the electrical accumulator car.

In the new system designed by Monsieur Conti it will be found that all these objectionable features have been done away with. The motive power is furnished by compressed air at a pressure of only about 44lb. (instead of 100lb. to 175lb., as in the Nogent system), stored in reservoirs carried beneath the car. But in order to avoid giving too great a weight to the vehicle, and to correct one of the principal defects mentioned in the Nogent motors, these reservoirs are only two or three in number, and of relatively small capacity—advantages which are gained by the ability to recharge the reservoirs (without interrupting the regular service, and upon the public street) by means of automatic feeding points. These feeding points are naturally established by preference near fixed stops.

Before and after the passage of a car, a little rectangular closed cover of cast iron at the level of the roadway between the rails, is the only external sign showing the existence of the automatic feeding point. The weight of the motor-car itself when it runs over the feeding point operates a sub-surface attachment, which opens the cover and instantaneously places the subterranean conduit between the tracks in communication with the reservoir of the car requiring a reinforcement of pressure. When the car again starts its weight operates the mechanism, which cuts off communication and hermetically closes the feeding point. As a few seconds only are necessary to complete the operation of recharging, the stop will never be greater than is usual at ordinary stopping places. Under ordinary conditions the distance between feeding points will be comparatively great, or on an average every mile and a half. As it is certain that within that distance there will always be found certain points at which a car must stop to take up or set down passengers, it will be seen that recharging will have little effect upon running time. Under such circumstances a car will always be ready to do its work. It will never need (as is obligatory in systems employing superheated water, electrical accumulators, or air accumulators of the Nogent type) to run into the carshed, or to pass near a charging station, in order to stop there more or less time.

So far as renewal of motive power is concerned, everything is done not only with great rapidity, but, moreover, by the aid of sub-surface appliances. No aerial material is required. Poles, wires, anchorages, stations upon one or more points of the line to provide compressed air or superheated water, are all done away with. This system interferes in no way with co-existent services, public or private, and as a consequence encounters no difficulties in obtaining franchises from municipal authorities. Owing to the system of feeding points along the line, a single power station can supply several lines at the same time, becoming, therefore, a veritable central station for the entire network of tramways of a city.

Compared with the Nogent motor heretofore mentioned, the weight of the new car, seating 50 persons, is reduced by more than one-third, and amounts to only 15,400lb. when empty. In order to gain a still higher economy, the motor is compound and the air is reheated twice. The motor being compound (or with two cylinders), can, according to its needs at various points of the route, work with either double or single expansion. By means of a special regulating apparatus, the several combinations by which the compressed air is admitted into the motor cylinders—for starting, regulation of power and speed, stopping, and brakes—operate in a cycle perfectly established and controlled. The various parts of the regulating apparatus are operated by a single handle, and only require in consequence a single movement.

The car body is mounted upon two independent frames, each one carrying an axle driven centrally by one of the two compound compressed-air motors, and having, moreover, freedom of motion around a vertical axis passing through its centre. Thus the two axles, each driven by a compound motor, are independent horizontally, which permits the operation of sharp curves. Moreover, as each motor drives upon the centre of its axle, all rocking motion is avoided completely. Furthermore, in order to avoid dead centres, and to share the work equally between the two axles, these are bound together by a special mechanical arrangement which keeps the angle of the cranks constant, the axles remaining always independent of each other horizontally.

The entire mechanism is hidden beneath the car body. The body itself remains completely independent of the frame upon which it rests. The platforms are entirely free. The driver on the front platform has nothing whatever to do but to operate two controlling handles. The car runs equally well in either direction. At a terminus the driver moves to the other platform carrying with him the two handles. The expense and inconvenience of turntables is thus avoided.

Cost of Production of Compressed Air and its Utilisation as a Motive Power for Tramways.

The cost per horse-power hour in compressed air reduced to atmospheric pressure, and utilised by motors of from 15 to 20 effective horse-power, has been established by numerous trials in Paris. Motors of the above power are principally employed in mechanical traction for tramways. The consumption of compressed air in a compound motor, such as is employed in the "Conti" system, the air being reheated before its admission to the cylinders to a temperature of 160deg. C., is 11·300 litres (9 944 gallons) per horse-power hour developed at the axle of the vehicle. To this cost it is necessary to add the losses in the distributing pipes, small escapes which may happen in the mechanism, and also the cost of operating the wheel brakes. We can assume a maximum loss of 10 per cent., which would put the actual consumption of air per horse-power hour at 12·430 litres, or 16·278 cubic yards.

Summary.

1. Steam horse-power hour at the station where the air is compressed, drawn in and compressed at a pressure of 20 kilos, or 44·091b. = 5·273 litres, or 6·897 cubic yards.

2 Amount of fuel at the station per horse-power hour including heating, pumps, accessories, etc., 1 kilo, 200 grammes, or 2·62lb.

3. One compressed air horse-power hour at the axle of the vehicle cost in atmospheric air 12·430 litres, or 16·278 cubic yards.

4. For reheating the air per horse-power hour 0·200 gramme, or 0·42lb.

5. The result of operating the Nogent lines of tramways by compressed air establishes the fact that a car loaded with 52 persons, upon a line 13 kilometres, or 14,207 yards, with maximum grade of 52 millimetres per metre, requires 8·800 litres, or 11·510 cubic yards of compressed air per car kilometre. (A kilometre equals 1,094 yards.)

Conclusions.

It is clear that a new system of mechanical traction for tramways will have chances of adoption proportionate to its gain in economy of operation: reduction in expenses being desirable at once in cost of production at the station, in the motor, and in the consumption by the motor of power. But it is also necessary that the system be easy to work and direct, and, moreover, absolutely beyond the possibility of sudden interruption from accident. It is also necessary that the system proposed should be easily understood by any tramway operator, and that it should not be necessary to preface its consideration by long special technical study.

In the present state of the art of mechanical traction as applied to tramways, it is evident that if economical operation be desired, the supply of power from a central station is indispensable. Operation by electric conductors carries with it many difficulties for the operator, largely arising from the inevitable complications

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of a service requiring such special knowledge as to make an expert technical staff in constant surveillance a necessity. With compressed air the method of operation is so simple that there is no necessity for long study of an expert nature before undertaking the handling of that system, while it is at the same time so regular and sure that one is not kept constantly on the alert, as is the case with the electric line. It follows that the manager of a compressed-air tramway can really direct its operation without being always at the discretion of an engineering staff, since he is free from apprehension of any serious trouble in his service. To handle an air-compressor is as simple as a pump. Any ordinary mechanic can undertake its management. The air being stored in advance in great quantities at a time in the reservoirs of the central station, in the distributing pipes, and in the tanks of the motor, interruption of service is practically impossible.

One of the most important advantages of compressed air is that it lends itself so well, incomparably better than any other system, to direct storage, which quality admits of holding in reserve great accumulations of energy with so much ease and economy. So far as accumulation of reserve power is concerned, electricity has incontestably shown itself greatly inferior to compressed air. Moreover, with compressed air, one has not to dread the deterioration of generating apparatus at the station on account of the sudden strains to which it is subjected by the interruption of current at the moment of stopping the motor, as is the case with an electric system. The reactions which so often have such disastrous effects upon generating dynamos are completely absent from compressed air generating apparatus. The latter being thus free from one of the most serious causes of deterioration, can, in contrast with electric installations, be operated for long periods without repairs. It should be also borne in mind that where the elevated electric conductor is employed, the operation of the line is always exposed to serious interruption. It is always possible for an evil-disposed person to throw the whole line out of service. It is unnecessary to rehearse here the many other objections to the use of the aerial wire.

As we have already stated, the result of the numerous comparative trials demonstrates that the cost of traction by compressed air is not higher than with the trolley-wire system. It would seem undeniable that, at the same cost, the compressed air system possesses undoubted advantages over the electric in all that regards the convenience, the comfort, and the security of the public.

THE ROYAL COMMISSION ON ELECTRICAL COMMUNICATION WITH LIGHTHOUSES AND LIGHT-VESSELS.

THE SECOND REPORT OF THE COMMISSION.

In our last issue reference was made to the fact that the Royal Commission appointed to enquire what lighthouses and light-vessels it is desirable to connect with the telegraphic system of the United Kingdom by electrical communication, had issued the second report. The members of the Commission are as follows: the Earl of Mount-Edgcumbe (chairman), Mr. Henry Lyle Mulholland, Sir Edward Birkbeck, Bart., Sir F. L. McClintock, Sir G. S. Nares, Mr. W. H. Preece, Mr. J. C. Lamb, Mr. John A. Kempe, and Mr. R. Munro-Ferguson. The following is the second report:

Since the issue of our first report, we have made a further tour of inspection of lighthouses and light-vessels. On July 10, 1893, we assembled at Glengariff, Bantry Bay. On the following morning we embarked on board the steamer "Moya," which was placed at our disposal by the Commissioners of Irish Lights, and inspected the Bull Rock and the Fastnet. Leaving the "Moya" at Baltimore we proceeded to Cork, and thence to Kingstown, where we embarked on board H.M.S. "Enchantress." On the morning of July 13 we proceeded to the Isle of Man, landed at the Chicken Rock Lighthouse, and, passing Langness Lighthouse and the Bahama Bank light-vessel, anchored in Ramsey Bay. On the following day we crossed from the Isle of Man to Bangor, county Down, passing the South Rock and Skulmartin Rock light-vessels and Mew Island Lighthouse. On July 15 we proceeded to Lamlash, landing on the way at the Maidens and Ailsa Craig Lighthouses. After having visited Pladda Island Lighthouse, we landed on July 17 on Sanda Island and Rathlin Island, inspecting the lighthouses on those two islands, and anchored for the night in Lough Foyle. From Lough Foyle we proceed to Oban, after having inspected the lighthouse on Inishtrahull Island, and from Oban we steamed through the Sound of Sleat to Stornoway. Returning to the mainland, we anchored at Loch Inver, and visited the Ru Stoer Lighthouse, and on July 24 we left Loch Inver for Longhope in the Orkney Islands, whence we paid a visit to the Cantick Lighthouse and to the look-out station of the Commissioners of Northern Lighthouses on Brough Ness, opposite to the Pentland Skerries Lighthouses. On July 26 we inspected Stroma and disembarked at Scrabster. Then proceeding south by train to Seahouses, we embarked on board the Trinity House steamer "Argus," which conveyed us round the Farn Islands. The tour of inspection ended with the visit to the lighthouses on those islands. We reassembled in London in September, and have since held several meetings.

Although the general question of signalling had not been directly referred to us, it appeared to be so intimately connected with the subject of electrical communication that we felt ourselves justified in considering it, and in our first report we stated that in cases "where the distance from the shore is not great, an improved system of distress signals (distinct from the usual fog signals) might, both at rock stations and on light-vessels, prove an effective temporary substitute for the more costly expedient of electrical communication." This view has been confirmed by the experience which we gained during our last tour of inspection, and we are now prepared to go further and recommend that the general lighthouse authorities should be invited to consider the subject with the view of instituting a universal system of visual and sound signals at all the various light stations on the coasts of Great Britain and Ireland. A member of the Commission, Sir Edward Birkbeck, having occasion last spring to visit the United States of America, we requested him to take the opportunity of enquiring into the systems of coast communication in force in Canada and the United States. On his return to this country, Sir Edward Birkbeck submitted to us a report, a copy of which will be found in the appendix. From that report it will be seen that, while both Canada and the United States possess an efficient system of electrical communication round their coasts, none of the light-vessels belonging to those countries had been electrically connected with the mainland.

We have received and considered particulars of a number of inventions for effecting electrical communication between light-vessels and the shore, but none of these are, in our opinion, preferable to the "Sunk" system, which is now being applied to the Goodwin (north sand head) and Kentish Knock light-vessels. We have again to express our obligation to the Admiralty for the loan of H.M.S. "Enchantress," and to the Trinity House, the Commissioners of Irish Lights, and the Commissioners of Northern Lighthouses for the assistance which they have rendered to us.

Recommendations.—We recommend that electrical communication by aerial wires be established without delay between the telegraphic system of the country and the following shore lighthouses and lighthouse stations:

Name of lighthouse.	To be connected by telephone with	Estimated cost (approximate).
Falmouth Harbour	Portscatho C.G.S.	£160
Souter Point	Whitburn C.G.S.	100
Montrose (Scurdy Ness)	Usan C.G.S.	85
Covesea Skerries	Lossiemouth P.O.	83
Tarbet Ness	Portmahomack P.O.	55*
Look-out station at Brough Ness for Pentland Skerries Lighthouses	St. Margaret's Hope P.O.	233
Fair Isle (north end)	Fair Isle P.O.	128
Sumburgh Head (Shetland Islands)	Sumburgh P.O.	65
Cape Wrath	Durness P.O.	20*
Ru Stoer	Stoer P.O.	20*
Rhynns of Islay (Oversay Island)	Bruichladdich P.O.	330
Turnberry	Maidens P.O.	48
St. Bees	St. Bees P.O.	76*
Langness	Castletown P.O.	103
Menai	Beaumaris P.O., and lifeboat coxswain's house at Penmon.	72
South Stack	Holyhead C.G.S.	15
Galley Head	Dunny Cove C.G.S.	150
Loop Head Kilcradan Point	Carrigaholt P.O.	61*
Total		£1,804

* If Admiralty wire is used.

It is with regret that we have decided to confine our recommendations in this report to shore lighthouses, but until more has been done towards effecting the connection of those light-vessels and lighthouses which were selected in our first report as having the strongest claims to immediate attention, we hesitate to add to the list of light-vessels and island and rock lighthouses with which we consider that electrical communication should be established.

THE PACIFIC CABLE SCHEME.

In view of the Colonial Conference to be held in June at Ottawa (says the *Times*) at which the scheme for a cable between Australia and Canada is to be considered, representations have been lately made to the Colonial Office. The advocates of the undertaking urge that the British Government should unite with the Governments of Australasia and Canada in guaranteeing the interest upon the capital required for a single line of cable. The Intercolonial Conference at Wellington considered that a guarantee of 4 per cent. upon a capital not exceeding £1,800,000 for 14 years would be sufficient to induce a company to undertake the construction of the line. But Mr. Sandford Fleming, the chief Canadian promoter of the scheme, thought that a joint guarantee of 3 per cent., representing a total charge of £52,350, would be sufficient, while the Colonial Conference thought £72,000 would be needed. Mr. Sandford Fleming suggests five routes, his object being to touch only at places where British influence is supreme. But the Wellington Conference proposed

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that the cable should touch at both the Sandwich Islands and Samoa.

In opposition to the scheme important representations have been submitted to the Marquis of Ripon on behalf of the cable companies which control the existing lines between the United Kingdom and Australasia. They urge that the existing service was established solely by private enterprise, no Government subsidy, guarantee, or exclusive landing rights having been granted to the company. A cheap tariff was tried in 1891-92 and resulted in a loss of £55,000, borne equally by the guaranteeing Australian Governments and the company. For the second year the loss amounted to £43,500, when the Governments concerned were instrumental in raising the tariff from 4s. to 4s. 9d. on January 1, 1893. The loss for the current year is estimated at £12,000. It is urged that as the present cable is duplicated throughout, and capable of carrying a far greater traffic than at present, an additional service is not wanted, and that the cost of £2,000,000, or £4,000,000 if duplicated, would end in ruinous competition. Moreover, if the Imperial Government joined in the proposed guarantee it could not in equity refuse to assist the existing service to the same extent. Any diversion of route would also inflict a heavy loss on the Indian Exchequer. The present traffic between Europe and Australasia consists, roughly, of 1,300,000 words per annum, and is worth about £209,000 a year. If the tariff was reduced to 3s., this amount would be reduced to £119,000, leaving a loss of £90,000. If half the traffic was diverted *vid* the Pacific, this loss would be increased to £150,000. On the other hand, a Pacific cable carrying half the existing traffic would, it is urged, only earn at a 3s. tariff about £45,000, after deducting out-payments. On the other hand, in order to meet its liabilities, it would have to earn £237,000, as shown in the following table :

Capital		£1,800,000
Working expenses	£25,000	
Maintenance	35,000	
		£60,000
Amortisation to replace cable at end of 14 years' guarantee		105,000
Four per cent. interest on capital		72,000
		£237,000
Leaving—after deducting estimated earnings as above	£45,000	
And the proposed 4 per cent. guarantee	72,000	
		117,000
A deficit of		£120,000

RESULTS OF EXPERIMENTS WITH THE HERMITE SYSTEM AT BREST.

We have received a copy of a report translated from the French and relating to experiments made at Brest with electrolysed sea-water prepared according to the Hermite system. The report, which has been presented to the Municipal Council of Brest, has been drawn up by Dr. Piton. After detailing the experiments, Dr. Piton says :

Summary.

From all these experiments that I have made it follows :

1. That electrolysed sea-water is relatively stable, and the higher the strength the greater the stability.

At 1 gramme per 1,000 it loses $\frac{1}{10000}$ per day.
At 0·75 " " $\frac{2}{1000}$ "
At 0·50 " " $\frac{3}{1000}$ "
At 0·25 " very unstable.

At the end of 24 hours' solution at 0·25 gramme contains an exceedingly feeble quantity of chlorine.

2. That the mixture of electrolysed sea-water with sea-water is very unstable.

3. That the mixture of electrolysed sea-water with fresh water is as stable as if two electrolysed solutions were mixed together, showing the possibility of transporting a concentrated solution to a distance, and reducing the strength with fresh water at the point required for use.

4. As a deodoriser the electrolysed sea-water is perfect.

5. That electrolysed sea-water does not dissolve fæcal matter, or paper, appreciably.

6. That it requires : (*a*) six litres of electrolysed sea-water at one gramme to sterilise one stool of 150 grammes ; (*b*) seven litres at 0·75 ; (*c*) nine litres at 0 50 ; (*d*) 10 litres at 0·36 ; (*e*) 12 to 15 litres at 0·25.

7. That electrolysed sea-water at one gramme, given equal volumes, is sufficient to sterilise a liquid stool in five minutes.

8. That it only take five minutes with solution from 1 to 0·75 to sterilise, in equal volumes, a culture of pure cholera or typhoid bacillus.

9. That it takes 10 minutes, with an equal volume of solution at 0·5 gramme and cholera bacillus, to sterilise the latter.

10. That it requires 15 minutes with solution of one gramme, and with equal volumes, to sterilise the "bacillus subtilis."

11. That an intimate contact is absolutely necessary—showing the necessity of retaining the materials in a cesspool or syphon before allowing it to run into the drain.

Conclusion.

The experiments that I have made lead me to the conclusion that electrolysed sea-water is a perfect deodorant and an excellent antiseptic, which rapidly destroys the most hardy micro-organism, always assuming a good contact between the micro-organism and the electrolysed solution.

In closing this report, I must request Dr. Vergos, doctor of the first class in the navy ; Dr. Parin, doctor to the colonies ; and Drs. Taburet and Ruelle (doctors of the navy), to accept my best thanks for their kind assistance in enabling me to finish these experiments rapidly upon the effect of the electrolysed sea-water upon the bacteria.

VESTRY OF ST. PANCRAS.

The following is an abstract of the published statement of accounts at December 31, 1893, under the St. Pancras Electric Lighting Order, 1893 :

Capital Account at Dec. 31, 1893.

Dr.	Expenditure to Dec. 31, 1892. £ s. d.	Expended during the year. £ s. d.	Total expenditure to Dec. 31, 1893. £ s. d.
Lands, including law charges incidental to acquisition	10,827 0 0	—	10,827 0 0
Building and paving..	7,653 17 8	1,694 8 3	9,348 5 11
Machinery and plant..	24,378 17 1	742 17 1	25,121 14 2
Accumulators at generating and distributing stations	2,961 6 11	40 0 0	3,001 6 11
Mains, including cost of laying the mains and services and royalties	33,787 15 3	2,971 19 0	36,759 14 3
Public lamps	6,723 8 4	485 15 4	7,209 3 8
Meters, switches, etc.	1,556 3 9	1,122 15 5	2,678 19 2
Electrical instruments, etc.	284 16 3	72 17 11	357 14 2
Office and other furniture and fittings	186 7 4	40 16 6	227 3 10
Preliminary expenses	554 4 7	—	554 4 7
Total expenditure...	88,913 17 2	7,171 9 6	96,085 6 8
To balance of capital account			5,728 19 3
			£101,814 5 11

Cr.	Receipts up to Dec. 31, 1892. £ s. d.	Received during year. £ s. d.	Total receipts to Dec. 31, 1893. £ s. d.
Amount raised by loans	70,000 0 0	—	70,000 0 0
Temporary loans from bank	21,269 10 9	10,544 15 2	31,814 5 11
	£91,269 10 9	£10,544 15 2	£101,814 5 11

Revenue Account at Dec. 31, 1893.

Dr.	£ s. d.	£ s. d.
To Generation of Electricity.		
Coal or other fuel, including dues, carriage, unloading, storing, and all expenses of placing the same on the works	3,051 17 4	
Oil, waste, water, and engine-room stores	428 0 6	
Wages at generating station	1,629 18 11	
Sundry petty expenses	65 11 5	
Repairs and maintenance as follows : Buildings, £146. 1s. 3d. ; engines, boilers, etc., £592. 7s. 2d. ; dynamos, exciters, accumulators, etc., £155. 18s. 6d. ; other machinery, instruments and tools, £34. 14s. 6d.—£929. 1s. 9d.—less received for old material, £1. 5s. 6d.	927 15 11	
		6,103 4 1
To Royalties, etc.		
Licenses for mains laid on Crown property, etc.		14 13 0
To Management Expenses.		
Salaries—viz., engineer's department and clerical staff	639 1 7	
Stationery and printing	49 5 5	
General establishment charges	148 17 0	
		837 4 0
To Distribution of Electricity.		
Wages and other remuneration to linesmen, fitters, labourers	497 14 7	
Repairs, maintenance, and renewals of mains of all classes, including materials and labour	378 2 9	
Repairs, maintenance, and renewals of meters, switches, fuses, and other apparatus on consumers' premises.	15 3 4	
Gas and water at sub-station	2 11 7	
		893 12 3
To Public Lamps.		
Carbons	302 5 5	
Attending	351 0 11	
Repairs	77 17 0	
		731 3 4

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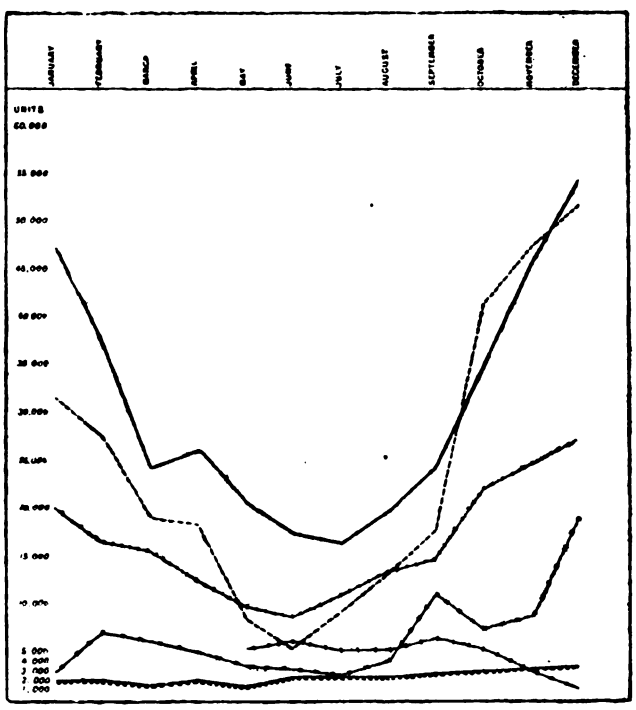
To Law and Parliamentary Charges.			
Law expenses		20 0 4	
To Special Charges.			
Insurances, etc.	59 5 9		
Expenses fixing meters, etc., on consumers' premises	150 16 8		
		210 2 5	
Total expenditure		8,809 19 5	
Balance carried to net revenue account		6,212 0 0	
		£15,021 19 5	

Cr.	£ s. d.	£ s. d.
Sale of current per meter at 6d. per B.T.U.	9,161 6 0	
Sale of current per meter at 3d. per B.T.U.	384 11 6	
		9,545 17 6
Public lighting		4,941 18 0
Rental of meters and other apparatus on consumers' premises		238 14 1
Rents from houses on spare land		125 15 7
Work done on consumers' premises		150 2 0
Sale of lectures and reports		19 12 3
		£15,021 19 5



Supply of Electricity in St. Pancras.—The curves reading downwards indicate: General supply at 6d. per B.T. unit 1893; general supply at 6d. per B.T. unit 1892; general supply ("day supply") at 3d. per B.T. unit 1893; general supply ("day supply") at 3d. per B.T. unit 1892; public lighting 1893; public lighting 1892.

Dr. Net Revenue Account, Dec. 31, 1893.	£ s. d.
Interest on mortgage debt accrued due to date	2,293 10 0
Interest on bank temporary loan	712 5 4
Bad debts	19 18 7
	3,025 13 11
Instalments paid off loans	1,628 11 6
Balance carried forward	1,557 14 7
	6,212 0 0
Balance net revenue account, 1892... £1,143 6 2	
Instalments paid off loan, 1892 400 0 0	
	1,543 6 2
Balance carried forward	14 8 5
	£1,557 14 7

Cr.	£ s. d.
Balance brought from revenue account	6,212 0 0
	6,212 0 0
Net balance, 1893	1,557 14 7
	£1,557 14 7

General Balance-sheet, Dec. 31, 1893.

Liabilities.	£ s. d.
Capital account—amount received	101,814 5 11
Sundry creditors	2,159 9 7
Interest accrued on loans	1,291 17 10
Net revenue account	14 8 5
	£105,280 1 9

Assets.	£ s. d.
Capital account—amount expended for works	96,085 6 8
Stores on hand at December 31, 1893—coal, £44. 7s. 6d.; oils, waste, etc., £27. 9s. 4d.; carbons, £9. 10s. 4d.; general, £931. 11s. 4d.	10,112 18 6
Sundry debtors for current supplied to December, 31, 1893	8,167 8 10
Cash in hand	14 7 9
	£105,280 1 9

LEGAL INTELLIGENCE.

EBBSMITH v. DAWSON AND OTHERS.

The action brought by Ebbsmith *v.* Dawson and others came before Lord Justice Coleridge and a jury on Wednesday. The case arose out of certain matters in connection with the South Staffordshire Tramways Company and the Electric Construction Company.

Sir Edward Clarke, Q.C., and Mr. G. Spencer Bower were for the plaintiff; and Mr. Murphy, Q.C., Mr. Blake Odgers, Q.C., and Mr. Hugh Fraser for the defendants.

Sir Edward Clarke, in opening the case, produced the circular containing the alleged libel, which in February, 1893, was issued by the defendants, who constituted the shareholders' committee of the tramways company, to their shareholders. This stated that whilst the shareholders in the South Staffordshire Tramways Company were being gradually educated to the idea of electric propulsion, and their authority obtained for the introduction of the necessary parliamentary measures, arrangements were being made in another quarter, apparently with the object of turning the profit to a good account, as on May 29, 1889, a company was registered in London under the title of the Electric Construction Company, in which Mr. Joseph Smith (now Ebbsmith), the present plaintiff, appeared as managing director, with a holding of £4,260, as against £200 in the tramways company, and that his former partner, Mr. George Roseurs, was the registered owner of £20,000, as against two shares held in the South Staffordshire Tramways Company, and the chairman of the latter company, Mr. Carruthers Wain, was holder of £3,000, as against £500 in the electric company. The circular further stated: "We find that Mr. Joseph Smith occupied the position of managing director until 1892, from the commencement of which his name ceased to be put forward in reports of the corporation, and it is curious to observe that Mr. Jabez Spencer Balfour and Mr. Henry Granville Wright, of Liberator notoriety, disappeared from the directorate at the time, and, for some reason or other, Mr. Smith changed his name at the end of 1892 by adding the prefix 'Ebb' to it; so that he is no longer Smith, but Ebbsmith." Sir Edward went on to say that the only conclusion which anybody could come to on reading the paragraph was that Mr. Smith, in using his earlier name as managing director of the Electric Construction Company, did so for the purpose of making money out of the South Staffordshire Company, and his interest in the Electric Company being so large, and his interest in the other so very small, he had made an arrangement for the benefit of the Electric Company. There was thus not the slightest foundation for the suggestions which had been made.

Mr. Ebbsmith was called, and corroborated counsel, stating that he changed his name at the request of his maternal grandmother, who was named Ebb.

The case was adjourned.

COMPANIES' MEETINGS.

EASTERN EXTENSION TELEGRAPH COMPANY, LIMITED.

The forty-first ordinary general meeting of the Eastern Extension, Australasia, and China Telegraph Company was held on Wednesday at Winchester House, Old Broad-street, Sir John Pender, M.P., in the chair.

The **Chairman**, in moving the adoption of the report and statement of accounts, reviewed at length the position and the prospects of the Company. The reduction in the expenses was partly due to the lower outlay in cable repairs, and partly to the increased revenue resulting from the raising of the Australian tariff, which was done at the request of the colonies, from 4s. to 4s. 9d. per word, and to the exceptionally heavy Australian traffic transmitted during the financial crisis last summer in connection with the numerous bank failures and reconstruction schemes. But for this there would have been a considerable falling off in revenue. The agitation for a Pacific cable between Canada and Australasia had greatly increased of late, but he did not think it would result in anything, as the line was too costly, and was not in reality required. The Governments interested had been advised by a conference held at Wellington to offer a guarantee for 14 years of 4 per cent. on a capital of £1,800,000, on condition that the tariffs were reduced to 3s. per word for ordinary telegrams, 2s. per word for Government telegrams, and 1s. 6d. per word for Press messages, but the cost of a duplicate line on that route would be £4,000,000,

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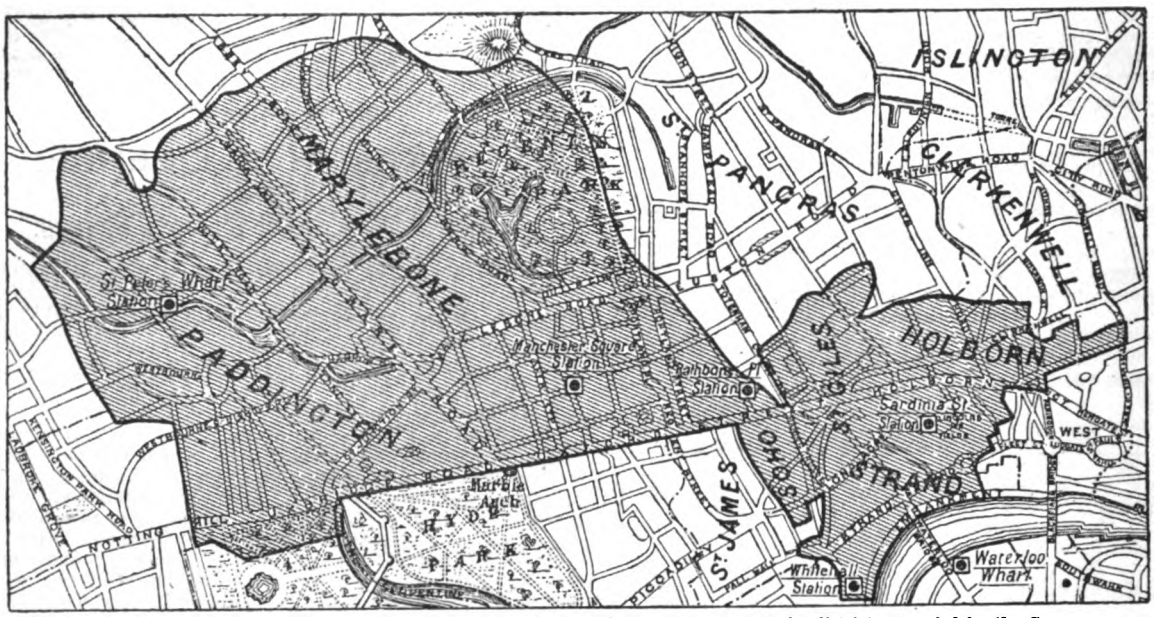
and was an unnecessary waste of money. But if such a line were subsidised, as their line was established by private enterprise, her Majesty's Government could not in equity grant pecuniary aid to such an undertaking without subsidising or guaranteeing their cables to the same extent. If, however, such a line was wanted for strategic purposes, it would be cheaper for the Governments concerned to arrange with them to do the work.

The **Marquis of Tweeddale** seconded the motion, which was passed.



Metropolitan Company.—Map of the Areas of Supply.—The shaded portions represent the districts occupied by the Company.

COMPANIES' REPORTS.

METROPOLITAN ELECTRIC SUPPLY COMPANY, LIMITED.

Report of directors to be presented to the shareholders at the seventh ordinary general meeting to be held at Winchester House, Old Broad-street, E.C , on Monday, April 23, at 12 o'clock noon.

The directors submit a statement of the Company's accounts for the year ending December 31, 1893, prepared in the form prescribed by the Board of Trade, under the provisions of the Electric Lighting Acts of 1882 and 1888. The capital expenditure, which at the end of 1892 amounted to £550,859. 16s. 11d., now shows a total of £585,932. 8s. 9d., being an increase during the year of £35,072. 11s 10d , principally owing to the continually growing extension of the Company's mains, to the cost of transformers and meters, and to providing connections to the premises of new consumers. The expenditure on buildings and machinery includes further payments on account of the Paddington plant, the sinking and fitting of a well for the more economical supply of water to the Sardinia-street station, and to works found necessary in connection with the foundations of the machinery at Manchester-square station. The gross revenue for the year amounted to £69,195. 4s. 4d., against £54,571. 19s. in 1892, being an increase of £14,623. 5s. 4d. as compared with the actual increase of £13,851. 19s. in 1892. A larger increase was fully expected, but the exceptional brightness and absence of fogs during the winter months had a serious effect in diminishing the demand for light In proof of this, it may be mentioned that while the revenue during each of the first three quarters of the year showed an increase of nearly 50 per cent over the corresponding periods in 1892, the increase for the last quarter was only 8 per cent., although there was no falling off in the growth of the lamp connection. The balance to the credit of the revenue account, before providing for depreciation, is £22,913. 15s. 2d. The directors have set aside £7,000 as an addition to the depreciation fund, carrying to the credit of the net revenue account the sum of £15,913. 15s. 2d., which, with the balance brought forward from the last account, and other receipts, make a total of £18,512. 16s. 4d. After deducting bank charges and debenture interest, there remains a balance of £14,548. 19s. 4d., of which the directors, in pursuance of the policy commenced last year, have appropriated a further sum of £1,000 in reduction of the preliminary expenses account, which is now diminished to £3,052. 10s. 4d. The directors recommend that a dividend of 5s. per share on the ordinary share capital be now paid, which will absorb a sum of £12,475, and leave a balance of £1,073. 19s. 4d. to be carried forward to the next account. The number of 8-c.p. lamps supplied by the Company increased during the year 1893 from 124,000 to 166,000. The present number of lamps connected is 175,000, and further applications continue to be received in satisfactory numbers. A report from the Company's chief engineer is appended, showing that the satisfactory condition of the stations, machinery, and plant has been maintained. The directors have to record, with the deepest regret, the death of two of their valued colleagues, Sir James Anderson and Sir George Elliot, both of whom had been members of the Board from the commencement of the Company. It is not proposed at present to fill the vacancies thus caused. In accordance with the articles of association, the following directors—viz., Admiral of the Fleet Lord John Hay, G.C.B., Joseph Charles Parkinson, Esq., and John Denison Pender, Esq.—retire from the Board, and, being eligible, offer themselves for re-election. The auditors, Messrs. Deloitte, Dever, Griffiths, and Co., also retire, and offer themselves for re-election.

Report of Chief Engineer.—I have pleasure in certifying that the Company's stations, machinery, and plant are being maintained in a satisfactory condition, and have worked without interruption up to the present date.

FRANK BAILEY, Chief Engineer.

REVENUE ACCOUNT FOR THE YEAR ENDING DEC. 31, 1893.

Dr.	£ s. d.	£ s. d.
A.—To Generation of Electricity.		
Coal or other fuel, including dues, carriage, unloading, storing, and all expenses of placing the same on the works	17,447 8 4	
Oil, waste, water, and engine-room stores	2,971 0 8	
Salaries of engineers, superintendents, and officers	1,755 3 0	
Wages and allowances at generating stations	6,466 14 8	
Repairs and maintenance as follows: buildings, £307. 17s. 1d.; engines, boilers, £3,695. 19s. 9d.; dynamos and exciters, transformers, motors, etc., £210. 4s. 11d.; other machinery, instruments, and tools, £1,252. 6s. 7d.; accumulators and accessories, £32. 13s. 11d.	5,499 2 3	
		34,139 8 11
B.—To Distribution of Electricity.		
Repairs, maintenance, and renewals of mains of all classes, including materials and laying the same	26 15 8	
Repairs, maintenance, and renewals of transformers, meters, and other apparatus on consumers' premises	191 5 0	
Pole rents and wayleaves	1 0 0	
		219 0 8
C.—To Rents, Rates, and Taxes.		
Rents payable Rates and taxes		3,606 11 0
D.—To Management Expenses.		
Directors' remuneration	2,175 0 0	
Salaries of management, secretary, engineers, accountants, clerks, and messengers	3,189 16 5	
Wages of meter readers and wiring inspectors	291 5 6	
Stationery, printing, and agreements	483 9 4	
General establishment charges	1,548 11 9	
Auditors	271 15 0	
E.—To Law and Parliamentary Charges.		
Law expenses		54 11 10
F.—To Special Charges.		
Insurances		301 18 9
G.—To Depreciation Fund.		
Depreciation in buildings ,, plant, machinery, etc.		7,000 0 0
Total expenditure		53,281 9 2
Balance carried to net revenue account		15,913 15 2
		£69,195 4 4

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Cr.	£	s.	d.
Sale of current, less reserve for doubtful debts, allowances, etc.	64,312	8	5
Rental of meters and other apparatus on consumers' premises	4,521	11	4
Rents receivable	87	0	0
Transfer fees	54	0	6
Special items—Net proceeds of work done for and goods supplied to sundry consumers	156	18	1
Surplus properties—rents and profits after deducting cost of repairs, rents, rates, taxes, and expenses of management	63	6	0
	£69,195	4	4

CAPITAL ACCOUNT YEAR ENDING DEC. 31, 1893.

	Expenditure to Dec. 31, 1892. £ s. d.	Expended during the year. £ s. d.	Total expenditure to Dec. 31, 1893. £ s. d.
Lands, including law charges incidental to acquisition	12,388 18 9	—	12,388 18 9
Buildings	133,429 13 6	3,073 3 11	136,502 17 5
Machinery	154,355 19 11	2,482 0 8	156,838 0 7
Accumulators at generating and distributing stations	6,742 12 7	—	6,742 12 7
Mains, including cost of laying the mains	129,539 18 11	12,099 1 9	141,639 0 8
Transformers, motors, etc.	48,820 16 1	13,754 1 3	62,574 17 4
Meters, and fees for certifying under the Act	7,955 6 10	9,906 1 3	10,861 8 1
Electrical instruments, etc.	1,336 5 11	211 2 2	1,547 8 1
Station fittings (cable, mains, lamps in station)	2,013 4 8	188 7 10	2,201 12 6
Parliamentary expenses, cost of licenses, provisional orders, etc.	7,620 8 2	—	7,620 8 2
Expenditure on offices, including furniture at offices, stations, etc.	2,539 17 6	124 8 3	2,664 5 9
Proportion of management and general expenditure, chargeable to capital—viz., engineer's department, including consulting engineer's, maps, plans, etc.	12,485 12 0	—	12,485 12 0
Law, auditors', and accountants' charges	1,450 5 11	—	1,450 5 11
Rent, rates and taxes, salaries, directors' fees, and other expenses	26,868 18 2	—	26,868 18 2
Special items—Expenses relating to compensation for damage, and cost of properties acquired	3,311 18 0	234 4 9	3,546 2 9
	550,859 16 11	35,072 11 10	585,932 8 9
To balance			13,809 0 3
			£599,741 9 0

Cr.	Receipts to Dec. 31, 1892. £ s. d.	Received during the year. £ s. d.	Total receipts to Dec. 31, 1893. £ s. d.
Ordinary shares of £10 each	498,741 9 0	—	498,741 9 0
Founders' shares of £10 each	1,000 0 0	—	1,000 0 0
Debentures at 5 p.c.	50,000 0 0	50,000 0 0	100,000 0 0
	549,741 9 0	50,000 0 0	599,741 9 0

Dr. GENERAL BALANCE-SHEET, DEC. 31, 1893.	£	s.	d.
Capital account—amount received	599,741	9	0
Sundry tradesmen and others, due on construction of plant, machinery, fuel, stores, etc.	13,525	6	0
Sundry creditors on open accounts	1,340	19	9
Depreciation fund	11,000	0	0
Net revenue account—balance at credit thereof	13,548	19	4
	£639,156	14	1

Cr.		£	s.	d.
Capital account—amount expended for works		585,936	8	9
Stores on hand—Coal	£471 4 6			
Oil, waste, etc.	578 15 4			
General	5,713 1 10			
		6,763	1	8
Sundry debtors for amounts paid on account of contracts in course of completion		2,520	12	9
Preliminary expenses	4,052 10 4			
Less charged to net revenue account	1,000 0 0			
		3,052	10	4
Sundry debtors for current supplied		26,608	14	3
Other debtors		606	3	1
Deposits (provisional orders, vestries, etc.)		1,030	0	0
Depreciation fund, investment account (£3,500 London and South-Western Railway pref. stock)		4,000	0	0
Cash at bankers—On deposit account	6,000 0 0			
On current account—Messrs. Prescott, Dimsdale, and Co.	1,793 0 11			
The Royal Bank of Scotland	809 11 4			
		8,602	12	3
Cash in hand		40	11	0
		£639,156	14	1

BUSINESS NOTES.

Western and Brazilian Telegraph Company.—The receipts for the past week were £2,603.

Hobart Electric Tramway Company.—For the month of March the earnings were £1,416.

Liverpool Overhead Railway.—The traffic receipts of this railway for the week ending 15th inst. amounted to £655.

Renfrew.—A large dredger launched by Messrs. Simons for the Russian Government is lighted throughout by electricity.

Sale of Plant.—Particulars of second-hand electric lighting plant for sale will be found in our advertisement columns.

West India and Panama Telegraph Company.—The receipts for the two weeks ended April 15 were £315 less than for the corresponding period of 1893.

Tenders for Exminster.—As will be seen by our advertisement columns, the Committee of Visitors of the Devon County Asylum desire samples of materials for wiring the asylum.

Southport.—No less than 1,400 yards of low-tension mains have been laid in the streets out of a total of 5,295 yards. The delivery of the high-tension mains was expected yesterday.

Tenders for St. Pancras.—It will be seen from our advertisement columns, that the St. Pancras Vestry invite tenders for the buildings to contain electrical plant at King's-road.

Fleetwood.—At a meeting last week of the Improvement Commissioners the clerk (Mr. J. Tidsley) said that complete specifications for the construction of the buildings had reached him.

Lancaster.—A circular has been issued by the Corporation informing intending customers for electric current that it was intended to commence a continuous supply on Tuesday last.

Eastern Telegraph Company.—The Company announce the payment by warrants on May 1 of interest for the half-year ending April 30 on their 4 per cent. mortage debenture stock.

Wakefield.—At a meeting of the Town Council, in reply to a question as to when the town would have the electric light, the Mayor explained that the provisional order had not yet been obtained.

Bedford.—Mr. Medhurst, the engineer, has been requested by the Town Council to draw up plans and estimates, with a view to tenders being invited for the erection of the central station and the supply of the plant.

Sale of Current.—The current sold by the St. James's and Pall Mall Electric Light Company, Limited, for the quarter ended March 25, amounted to £10,375, as against £10,119 in the corresponding period of 1893.

Islington.—At a meeting of the Islington Vestry last week the Clerk reported in regard to the electric lighting station site in Holloway-road that the mortgage for £9,000 with the London County Council was completed.

Southend Lighting.—An agreement with the gas company for public lighting has been sealed upon the town clerk's advice that it would in no way interfere with the lighting of the borough with electricity should such a decision be arrived at.

Tenders for Brighton.—As stated in our last issue, the Town Council invite tenders for the supply and erection of Willans engines, continuous-current dynamos, pipe work, spare armatures, etc. Tenders are to be sent in by the 30th inst.

Buxton.—At the last meeting of the Local Board there was a long discussion on the question of the town being lighted by electricity. The Chairman said nothing definite had been done so far. It was agreed to have a special meeting *re* the electric light.

Dover.—The surveyor has submitted to the Town Council the drawing he had received from the electric light company of the lamp columns, and it has been approved. The columns are of similar design to the large lamps on the sea-front, only that they are 21ft. in height.

A Wharf Crane Required.—As mentioned last week, tenders are required for a travelling jib landing crane, and also for a dynamo and lighting installation. Applications are to be sent to Messrs. C. H. Glover and Co., Hatcham Sawmills, Ormside-street, Old Kent-road, S.E.

Award.—Mr. H. Tompkins, in connection with the exhibition of blacksmiths' work held last week at the Ironmongers' Hall, Fenchurch-street, E.C., was awarded a prize for a handsome electrolier. Several electrical fittings in hammered iron were lent by a member of the Blacksmiths' Company.

Morecambe.—Complaints have been made to the Morecambe Local Board of alleged "stinks" from the electric light company's works, said to be due to the discharge into the air of the superfluous water gas. The medical officer has been instructed to report on the matter.

Bengal.—It appears that the agreement among the Bengal jute manufacturers is to run the mills only five days per week for three months from April 2. The owners of the Hastings mill have declined to join the movement at all, and the mill is being fitted up with the electric light for night work.

Ashton.—The Market, Lighting, and Cemetery Committee of the Town Council are of opinion that the question of electric lighting ought to be now considered, and they have requested the chairman of the General Purposes Committee to convene a meeting of the said committee to consider the matter.

City and South London Railway.—The receipts of the Company for the week ended April 15 were £840, against £861 for

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the same period last year, or a decrease of £21. The total receipts for the first half-year of 1894 show an increase of £9 compared with those for the corresponding period of 1893.

St. Pancras.—The tender of Messrs. Easton, Anderson, and Goolden for the supply of boilers for the King's-road electricity station, at £2,837. 6s. 2d., has been accepted. The tender of Messrs. Doulton and Co. for supplying the electricity station with a water-softening apparatus for £198, has also been accepted.

Edinburgh.—The following are the contractors for the supply of cables in connection with the Edinburgh Corporation's electric light station: unarmoured cable, Henley's Telegraph Works Company, Limited; arc lighting cable, Indiarubber and Telegraph Works, Company, Silvertown; armoured cable, Messrs. Siemens Bros.

Yarmouth.—A special sub-committee of the Town Council has been appointed to consider the present lighting of St. Andrew's Ward, and to report as to whether any improvement could be obtained in the quality and cost of the gas supplied to this ward. The Electric Lighting Committee have also been invited to make a report.

Chadburn and Son, Limited.—This Company has been registered with a capital of £30,000 in £1 shares, to enter into an agreement with William Chadburn, and to acquire and carry on the business of a patentee and manufacturer of ships' telegraphs, optician, and nautical instrument maker, now carried on by him at Liverpool.

Coventry.—At a meeting of the City Council a letter was read from the Electric and General Contract Corporation, Limited, asking the Corporation to delay taking any steps in the matter of the tramways for one month pending negotiations for the equipment of the line. It was ordered that the matter stand over for one month.

New Company—The business of Mr. John T. Bolding, trading at Grosvenor Works, Davies-street, London, W., as brassfounder and manufacturer under the title of John Bolding and Sons, has been converted into a private limited company. No shares will be offered to the public, all the shares being held by Mr. Bolding and the employés.

Clerkenwell.—The County of London and Brush Provincial Electric Lighting Company, Limited, are about to commence work in Clerkenwell. The Vestry has received a letter from the company to this effect, and also that the whole of the 19,900 shares of £10 each offered for subscription by the company have been allotted.

Windsor.—At a meeting last week of the Urban Sanitary Authority, Alderman Hollis said he was sorry to see no report from the Electric Light Committee appointed some time since. It was time something was done. The Deputy Town Clerk said communications had been made of the nature of which it would not be wise to make public.

Notting Hill.—The Notting Hill Electric Lighting Company have applied to the Kensington Vestry for permission to lay mains in a road which was not in the area specified by their provisional order, and the Vestry have informed the company that they would be prepared to consider any proposal that the company might make for dealing with a larger area.

Phosphor Bronze Company.—The twentieth annual general meeting was held on the 30th ult., Mr. Henry Seebohm in the chair. The directors' report and accounts were adopted. Mr. C. E. Taunton handed in his resignation as a director. Mr. Bernard Gibson was re-elected, and Messrs Francis W. C. Cuming and Richard E. M. Lagerwall were appointed directors, the last named to be a managing director.

Cockermouth.—The minutes of the Gas Committee presented at a meeting of the Urban Sanitary Authority last week, contained a recommendation that a new purifier, etc., be erected. Mr. Jefferson thought the expenditure of £1,000 on extensions of the gasworks in a place like Cockermouth was money thrown away. He asked how much the electric light would cost. The Chairman said the Board had been strongly advised not to go in for the electric light.

Electric Lighting at Richmond.—We learn that almost the whole of the best work in Richmond has been carried out by Mr. C. A. Hemingway, and among the many installations which he has up to the present completed may be mentioned the Greyhound Hotel, the Castle Buffet, Marshgate House (for Alderman Robinson), 5, Hill-street (for Wm. Burrell, Esq.), and about 15 business establishments. Mr. Hemingway has a large amount of work now in hand, and has already found it necessary to extend his premises.

Steam-Turbine for Electric Lighting.—A trial has been made at Messrs. Mavor and Coulson's electric works in Glasgow of the first of Laval's steam-turbine introduced in Scotland. The rate of speed is said to be the highest that a spindle has ever been run in machinery, and the steam acts upon the turbine by impact exactly as water does. The machine is largely used in Sweden for industrial purposes, but in this case it has been specially constructed for the electric light. Lord Kelvin has examined the turbine at work.

Tenders for Southampton.—The Southampton Harbour Board invite tenders for work comprised in the electric lighting of the Town Quay, Southampton. Plans may be seen and specifications and forms of tender obtained at the offices of the engineer, Mr. J. G. W. Aldridge, A.M.I.C.E., 9, Victoria-street, London, S.W., and 23, High-street, Southampton, upon payment of £2. 2s. (to be returned on receipt of a bona fide tender). Tenders to be delivered to Mr. A. H. Skelton, clerk, at the offices of the Board, Town Quay, Southampton, by May 8.

Edinburgh.—As we have already mentioned, an extension of the public lighting is being agitated for in Edinburgh. On Tuesday at a meeting of the Town Council, a letter was read from Mr. Robert A. Douglas, with a statement in favour of including George-street, St. Andrew-square, Charlotte-square, and the streets leading into these thoroughfares from Princes-street, in the electric lighting scheme. A deputation was heard on the subject. The deputation were informed by the Lord Provost that the matter would receive the attention of the Electric Lighting Committee.

Stafford.—At a meeting of the Town Council, the Electric Light Committee recommended the following tenders for acceptance: for the electric works—engines, Messrs. Robey, £2,288; boilers, Messrs. Hicks, Hargreaves, and Co., Bolton; dynamos, the Electric Construction Company, Wolverhampton, £1,151; buildings, Mr. J. Lovatt, Wolverhampton, £3,030; ironworks and roofs, Messrs. Rubery and Co., Darlaston, £197. The report was adopted, but owing to some misunderstanding about the tender of Messrs. Robey for the engines, this part was referred back to the committee.

New Installations in Manchester.—Messrs. Baxendale and Co., of Miller-street, Manchester, inform us that they have secured the following contracts: arc and incandescent lighting at Messrs. Hepworth's shops, Market-street, Manchester; incandescent lighting at Mr. Hedley, hairdresser, Fountain-street, Manchester; additional lighting at Messrs. Scarfpin and Co., Oldham-street, Manchester; incandescent lighting at Messrs. Hall and Co., Oldham; telephonic communication with fire station at Chorley Workhouse, Chorley; and telephonic installation at Messrs. Booth and Co., Hall-street, Manchester.

Dublin.—The Corporation on Monday adopted the report of the Electric Lighting Committee, submitting a statement of the income and expenditure from January 1 to December 31, 1893, inclusive. Mr. Robinson, in moving the adoption of the report, said he thought they had reason to congratulate themselves on a very satisfactory state of affairs. If they were a private company the city accountant told them that they would be able to pay a dividend of 4½ per cent., which was very satisfactory for a new undertaking. He hoped in a few years to make substantial profits; and he might say that, comparing matters with English municipalities, they were able with a small capital to supply the same quantity of electricity. With an extension of the plant they hoped to make their working more profitable still.

Bristol—The Electrical Committee of the Town Council have determined upon purchasing a small engine and dynamo, at a cost of £613, for the purpose of supplying the small amount of current demanded in the daytime. With this new machinery it is expected that a saving of about £400 per annum will be effected. A letter was read from Mr. Arthur W. Ranken resigning his appointment of chief assistant engineer. The committee accepted the resignation, and decided to promote Mr. E. H. B. Tyler (third assistant engineer) to the vacant appointment. The committee considered applications for the vacancy caused by Mr. Tyler's promotion, and appointed Mr. G. Gilbert Bell, of Lincoln, at weekly wages of £2. On a proposal to light St. Mary Redcliffe Church by electricity, the engineer was instructed to make enquiries as to the probability of the light being adopted by tradesmen and others of the neighbourhood in order that the scheme might be successful financially, and also to make enquiries and ascertain the financial prospect of extensions to Redland, Clifton, North-street, and Stoke's-croft.

Restaurant Lighting at Edinburgh.—An electric light installation has been carried out in the Grand Restaurant, Edinburgh, by Mr. Matthew Buchan, of the Waverley Electric Works, Portobello. On the occasion of the starting of the installation, Messrs. Daish and Co., the proprietors, entertained a large number of friends to dinner. Being the first restaurant in Edinburgh to be lighted by electricity, considerable interest was taken in the event. The chairman, Mr. H. G. Younger, was presented with a "Waverley" electric watch nightlight—a bedroom appliance, by which a person may, by touching a button, be able to perceive the time without difficulty. The motor is a gas-engine of the Otto type, and capable of developing 8½ b.h.p. From one of the flywheels a flexible link leather belt is used to drive the dynamo, which is of the compound-wound self-regulating type, as manufactured by the Electric Construction Company. It is designed to give a current of 50 amperes at 100 volts pressure when running at a speed of 1,150 revolutions, and is capable of lighting about 85 16 c p. incandescent lamps or their equivalent.

Fareham.—At a meeting of the Local Board last week, the following letter was read by the clerk from the secretary to the Fareham Electric Light Company, Limited: "At the annual general meeting of the shareholders of this company, held on Wednesday, March 21st ult., a resolution was passed authorising the directors to offer their business to the town of Fareham. I am, therefore, instructed to offer the business of the Fareham Electric Light Company, with all buildings, plant, machinery, mains, meters, and all other electrical and mechanical apparatus appertaining thereto, together with their provisional order, which secures to the company the sole and exclusive right to vend electricity within the Fareham Urban Sanitary Authority for a term of 42 years, as from the year 1892. The company are prepared to sell, and hereby offer to sell the aforesaid business, either at the cost price of the same as standing in the books of the company, or by valuation in the usual way, as your Board may consider advisable." The Chairman remarked that he was in rather an anomalous position, being the chairman of the electric lighting

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company. They would, however, remember that some years ago the gas company made a similar offer, and it was considered at a public meeting of the ratepayers. He thought they would have to take a similar course now. Mr. Sandy said it was clear that the Board could not determine the question. Mr. Abraham and other members agreed with Mr. Sandy, and it was resolved that a public meeting should be called on the 26th inst.

Taunton.—A report has been presented by a committee on the electric light to the Town Council, and has been adopted. The new engine and alternator are now being used at the works for the light loads. This will decrease the cost of working. The Government inspector has ordered that the belts and wheels at the works shall be fenced. Tenders have therefore been obtained for doing the work, and the committee have accepted that of Messrs. Allen and Son for the sum of £39. 7s. 8d. Mr. Harold W. Couzens has been appointed electrical engineer in charge at a salary of £120 per annum, to commence from January 1 last. The time for which Mr. Witham, jun., was taken as a pupil without salary has expired, and he will be paid £20 per annum, as an assistant, to commence from the 1st inst. A policy is to be taken out with the Boiler Insurance and Steam Power Company for £1,500 for the three boilers grouped, to cover all losses. Mrs. H. Howard has duly executed the indenture for the apprenticeship of her son, Archibald J. Howard, for a period of one year from October 1 last, and has paid the amount of the premium—viz., £50. Councillor Potter stated that the whole of the lighting on Good Friday and Easter Monday, when the shops were closed, was run from these new machines. Alderman Standfast thought the Electric Light Committee were drawing pretty near the end of their tether as regards expenditure of the loans. At present they had spent £12,635 out of the loan, and £1,638 by working expenses. Councillor Potter said the charge per lamp was just the same, and the increase in returns was due to the increase in the number of lamps and also in the number of hours. The working expenses thus far had been £1,495, and in that sum was included £133, which would not occur again, from small sundries taken over from the late company. The receipts were about £1,300.

Lighting Railway Tunnels.—Mr. Charles E. Parsons, of Newport, writes to the *Western Mail* as follows: "The plan at present adopted by most of our principal railway companies of lighting their carriages during the daytime with the old-fashioned and unsatisfactory oil lamps whenever the journey to be made includes one or more tunnels ought surely to give way to a cheaper, safer, and more effective system The cost of maintaining these lamps, which are burning to waste in daylight when the train is not running through a tunnel, must be far greater than the introduction of a simple system for electrically lighting the tunnels themselves by a switch arrangement, which could be operated upon by the engines turning the light on or off as they enter and leave the tunnels. An ordinary mechanical contrivance, such as a small switch level with the rail, could turn on the light on one side for the whole time any train (passenger, goods, or mineral) was passing through, and would have the great advantages of warning and of assisting all workmen or others in the tunnel to make themselves perfectly safe, instead of being obliged to run the terrible risks which are now of daily occurrence, and would also enable the engine-drivers to see their roads ahead. The turning-off switch might, in cases where tunnel repairs are being carried on, be disconnected, and thus a full and ample light be assured to the workmen, instead of the inadequate paraffin lamps and flambeaux now in use, while the turning-on switch could be disconnected at night when the carriages are fully lighted. Between Bristol and Cardiff there are three tunnels, and for a journey of one hour and a half the carriages are needlessly lighted for five-sixths of the day journeys. Many similar instances could, of course, be quoted."

Guildford.—At a meeting of the Urban Sanitary Authority last week the clerk submitted the following report of the result of an interview which the Mayor and himself had with the Board of Trade in reference to the application of a provisional order to enable a private company to supply the borough with the electric light: "We beg leave to report to the Council that in accordance with the instructions given at their meeting held on the 27th day of March last, we attended at the Board of Trade on the 31st day of March last at the meeting which had been appointed by the Board of Trade for the purpose of giving the Corporation and the promoters of the Guildford electric lighting order an opportunity of placing their views before the Department. After the representatives of the promoters had stated their case, relying greatly upon the provisions of the Electric Lighting Acts, as to the term of purchase being 42 years, we represented to the Board of Trade that the Town Council were of opinion that the electric lighting of the borough should be in the hands of the local authority, but that as the Council were not prepared to undertake the work at once, they had resolved to give their consent to the granting of the provisional order to the promoters only on the condition on which it had been given—namely, that the Council should be entitled to purchase the undertaking at the expiration of 10 years from the date of the order on the terms set forth in the second section of the Electric Lighting Act, 1888, and we also explained the circumstances under which, after such consent had been given, the Council had been advised by Mr. Phillips that the surplus water power at the Guildford Mills might with advantage be utilised in providing a supply of electric light in the borough. The representatives of the Board of Trade then enquired whether we were authorised to name a period within which the Corporation would undertake to carry out the work themselves, and on our stating that we were not authorised to give any undertaking which would bind the Corporation to carry out the work themselves within a definite period, the gentlemen representing the Board of Trade intimated that the Board of Trade would be advised under the circumstances to dispense with the consent of the local authority to the granting of the provisional order to the Holloway Electricity Supply Company, Limited, and added that the Board of Trade would be prepared to consider any representation that might be made to them by the Corporation for the insertion in the provisional order of clauses which would give the Corporation power to acquire the undertaking at some period before that fixed by the Electric Lighting Acts of 1888, provided that such representation were sent to the Board of Trade without delay." The Mayor said he thought they might, perhaps, try to get powers to purchase the undertaking in 30 years, but he did not believe they would ultimately do any good by any other proposition, and he had not a very hopeful view as to that one. Unless they could support their application on very strong grounds they could not derive very much benefit. The statute laid down 42 years, and if the local authority would not proceed to supply electricity he did not think the financial question between them and the company would be a matter in which the Board of Trade would take much trouble about. Alderman Allen did not think that they would be doing right to the ratepayers to allow a monopoly of the character proposed to come into the town for the long period of 42 years. He suggested that a committee should be appointed to consider the matter. The Mayor suggested that an application be made to the Board of Trade to reduce the term of years to 30. Alderman Allen moved that a request be made to the Board of Trade that a clause be inserted in the provisional order giving power to the Corporation to take over the undertaking on the statutory terms at the end of 30 years. Alderman J. Mason seconded the motion, but said that he did so as a matter of form, as he did not think it would do any good to them. The resolution was carried by seven to five.

Trades Union Question at Portsmouth.—The recent appointments made by the Electric Lighting Committee of the Portsmouth Town Council in connection with their new works are regarded with disfavour by local trades unionists, and particularly by the members of the Amalgamated Society of Engineers. The members of this society feel that the claims of the electricians among the ranks of their important trade organisation have not received the consideration to which they are entitled under the resolution adopted by the Corporation a short time since, adopting the principle of paying "the current rate of wages" to all workmen in the service of the municipal authority. The terms of the advertisement inviting applications for the appointments to be created by the installation of the electric light in the borough have been severely criticised by the local branches of the society, and with a view to bringing about a satisfactory readjustment of the matter, a deputation consisting of the president and two delegates, representing the District Committee, sought an interview last week with Alderman G. Ellis, and T. Scott Foster, chairman and vice-chairman of the Electric Lighting Committee respectively. The president observed that the organisation embraced electrical engineers, and fixed the minimum rate of pay for all members employed in this division at 36s. per week. Their present ground of complaint was that the remuneration offered by the Electric Lighting Committee to the mechanical engineers engaged for the new works was considerably below the current rate of wages. Alderman Ellis informed the deputation that the officials referred to were not mechanical engineers. He admitted that the advertisement was wrongly framed, and hence a misunderstanding had arisen. The gentlemen appointed by the committee should properly be described as "assistant superintendents." They probably had some knowledge of mechanical work, but were by no means trained to the use of tools like fitters who had served an apprenticeship to their trade. Nor were they required to do the work of a fitter. They would have to deal with no fewer than 13 dials and work out mathematical calculations, in order that the power might be properly given according to the varying requirements of the consumers. The Board of Trade insisted that scientific men should be employed upon such important duties, and he would not for a moment hold himself responsible for what might occur in the event of the work being placed in the hands of men who had not received that scientific education which could alone ensure their fitness for the work. Alderman Scott Foster pointed out that the three young gentlemen engaged as assistants under Mr. Price, the superintendent of the new works, occupied positions analogous to those of nearly all physicians, just qualified in the medical profession. They had been articled to electrical engineers, and having spent several years in the capacity of students, took up positions at nominal salaries under superintendents of important electrical works, with the object of gaining as much experience as possible, and thus qualifying for superior appointments. The President said that his society did not recognise them as electrical engineers, because in the opinion of the members they were being drafted into certain positions with the object of robbing them of the work which should belong to their trade alone. Two of the deputation were electricians who could design, construct, and work the whole of the committee's machinery. The men appointed might be able to make mathematical calculations, but the moment anything went wrong with the plant they would be compelled to fly to mechanics for the execution of the repairs. Was it right or just that men who could not be relied upon to set matters straight in case of emergency should be employed on work which properly belonged to fitters? Alderman Foster said that they were not there to argue that matter. The question at issue was, "Do these three men come under the rules of your society?" The committee had consulted eminent electrical engineers, who told them positively that it was necessary to have these scientific men at their works. Alderman Foster

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repeated that the Amalgamated Society of Engineers had nothing to do with the three assistant-superintendents, who were in the same position as Mr. Price, with the exception that they did not receive so much remuneration. They wished to come there for further experience. A delegate complained that the advertisement relating to the appointments was not published in time to find its way into the electrical papers. Alderman Foster said that the committee issued no advertisement with regard to the appointment of mechanical engineers. They had promoted Mr. Randall and two others who had been working under him at the Town Hall. The Chairman said that the interview would be reported to the committee, and he had no doubt that the representations of the Amalgamated Society of Engineers would receive every consideration at the hands of the committee as long as they were confined to men belonging to the society.

PROVISIONAL PATENTS, 1894.

April 9.

7050. **Improvements in electrically-illuminated signs.** Guy Carey Fricker, 46, Lincoln's-inn-fields, London.

7054. **Improvements in electrically-propelled vehicles.** Ernest John Clubbe and Alfred William Southey, 53, Chancery-lane, London.

April 10.

7080. **Improvements in phonographs.** Joseph Oulton, 2, Market-street, Bradford.

7094. **Improvements in and connected with secondary electric batteries.** William Joseph Starkey Barber-Starkey, 70, Market-street, Manchester.

7116. **Apparatus for calling any desired station on a telegraphic or telephonic line.** Charles Bradbury, 249½, High Holborn, London. (Franz Trinks, Germany.) (Complete specification.)

7121. **Improvements in electric car lighting apparatus.** William Biddle and Patrick Kennedy, 33, Chancery-lane, London.

7145. **Improvements in or connected with the electro-deposition of metals or metallic compounds and the treatment of deposited metals or compounds.** Sherard Osborn Cowper-Coles and Baldwin Wake Walker, Bart., 47, Lincoln's-inn-fields, London.

7148. **Governor for electric, water, and other motors.** Nathaniel Shepard Keith, 24, Southampton-buildings, Chancery-lane, London.

7155. **An improved multiple distributing electric cut-out.** Albert Higgins, 48, Osnaburgh-street, Regent's Park, London.

7165. **Improvements in secondary voltaic batteries.** Ernest John Clubbe and Alfred William Southey, 53, Chancery-lane, London.

7176. **Improvements in and relating to telephonic systems.** Henri Carbonnelle, 45, Southampton-buildings, Chancery-lane, London.

April 11.

7205. **A new or improved process for the electro-deposition of aluminium and aluminium alloys.** Alfred Francis Bilderbeck Gomess, 24, Alfred-place West, South Kensington, London.

7206. **A new or improved process for the electro-deposition of aluminium and aluminium alloys.** Alfred Francis Bilderbeck Gomess, 24, Alfred-place West, South Kensington, London.

7214. **Improved safety arrangement for electric miners' lamps.** Howard Vivian Coad, 37, Cursitor-street, Chancery-lane, London.

7215. **Improvements in electric printing telegraphic apparatus.** Eugene Magnin, 65, Chancery-lane, London. (Complete specification.)

7216. **An improvement connected with electric switches.** Richard Hurst, 166, Fleet-street, London.

7238. **Improvements in or relating to electric telephones.** Sir Charles Stewart Forbes, Bart., 45, Southampton-buildings, Chancery-lane, London.

7239. **Improvements in alternating-current electric motors.** Carl Coerper, 45, Southampton-buildings, Chancery-lane, London. (Complete specification.)

7244. **Improvements in apparatus for electrically recording circular, longitudinal, or transverse motions of mechanical devices.** William Hopkin Akester and Henry Hubert Price, Granville House, Arundel-street, Strand, London.

April 12.

7258. **Improvements in electric arc lamps.** Gustav Binswanger and Herbert John Coates, 71, Queen Victoria street, London.

7287. **A method of electrically lighting vehicles by their own momentum.** Stuart Robson, 210, Brixton-road, London.

7307. **A new or improved electrical appliance for sounding an alarm when any desired temperature is reached, also serving as a fire alarm.** Charles Balbiani, 22, Glasshouse-street, Regent-street, London. (Complete specification.)

7311. **Improvements relating to secondary batteries.** Bernar c Alfred Nicolas Dorez, 45, Southampton-buildings, Chancery-lane, London.

7322. **An improved electric central alarm or call apparatus.** Conrad Christgau, 1, Queen Victoria-street, London. (Complete specification.)

April 13.

7396. **An electric contact apparatus worked by railway trains.** Edward Tyer, 28, Southampton-buildings, Chancery-lane, London.

7402. **A new or improved gas or electric light regulating apparatus for railway stations.** Laurence Barnard Tappenden, 37, Chancery-lane, London.

April 14.

7467. **Improvements in primary electric or secondary batteries.** Augustus John Marquand and Emmanuel Hancock, 24, Southampton-buildings, Chancery-lane, London.

7468. **Improved method of and apparatus for distributing electrical energy by means of alternating currents.** Engelbert Arnold, 28, Southampton-buildings, Chancery-lane, London.

7477. **Improvements in apparatus and means for vulcanising small articles, more especially intended for vulcanising the insulation at the joints of electric conductors.** Henry Edmunds, 47, Lincoln's-inn-fields, London.

7479. **An improved electricity meter for registering the amount of current consumed on direct, or alternating, polyphase, triphase, or quadruplephase circuits.** Frederick John Beaumont and Frederick Hallows, 166, Fleet-street, London.

SPECIFICATIONS PUBLISHED.

1882.

1862. **Electrical railways or tramways.** Handford. (Edison.) (Second edition.)

1892.

9346. **Electrolysis of chlorine, etc.** Kelner. (Second edition.)

1893.

6233. **Electric clocks.** Du Bois.

6306 **Electric current meter.** Nielsen.

6780. **Secondary batteries.** Doubleday and Sussmann.

9641. **Signal for telephone circuits.** Hall and Pickernell.

10015. **Utilising electrical energy for culinary purposes.** Crompton and Dowsing.

24864. **Dynamo-electric machines.** Thomson.

1894.

3273. **Arc lamps.** Chester and Rathbone.

3730. **Electric arc lamps.** Claremont.

COMPANIES' STOCK AND SHARE LIST.

Name.	Paid.	Price Wednesday.
Birmingham Electric Supply Company	5	5¼-5⅜
Bournemouth Electric Company	—	—
Brighton and Hove Company	—	—
Brush Company, Ordinary	3	2⅞-3⅛
—— Nom. Cum , 6 per cent. Pref.	2	2⅛
—— 4½ Debenture Stock	100	106-108
Charing Cross and Strand	5	4-5
Chatham and Rochester	—	—
Chelsea Electricity Company	—	—
City of London, Ordinary	10	11½-12½
—— 6 per cent. Cumulative Pref.	10	13½-13⅝
City and South London Railway, Consolidated Ordinary	100	27-32
—— Debenture Stock	100	108-108
—— 5 per cent. Pref. Shares	10	10¼-11
Crompton and Co., 7 per cent. Cum. Pref. Shares	5	3¼-4
—— 5 per cent. First Mortgage Debentures—1-400 of £100 and A, 1-200 of £50	—	95-100
Elmore's French Company	3	⅛-⅜
Electric Construction, Limited	2	⅛-⅜
—— 7 per cent. Cumulative Pref.	2	1½-1¾
Elmore's Copper Depositing	2	½-¾
Electricity Supply Company for Spain	5	—
Elmore's Wire Company	2	½-¾
Fowler-Waring Cables	5	½-1½
House-to-House Company	5	½-1
India Rubber and Gutta Percha Works	10	23-24
—— 4½ per cent. Debentures	100	101-103
International Okonite, Ordinary	10	1-2
Kensington and Knightsbridge	5	4¾-5¼
Liverpool Electric Supply, Ordinary	5	6⅛
—— Pref.	4½	5⅛
London Electric	5	⅝-1⅛
Metropolitan Electric Supply	10	7½
—— 5 per cent. Reg. Debentures, 1-10,000 in Bonds of £10, £20, and £40	—	106-109
National Telephone, Ordinary	5	4⅛-4¼
—— 6 per cent. Cum. First Pref.	10	14½-15½
—— 6 per cent. Cum. Second Pref.	10	14-15
—— 5 per cent. Nom. Cum. Third Pref.	5	5⅜ 5⅝
—— 4½ per cent. Deb. Stock	—	115-117
Notting Hill Company	10	4½-5⅛
Oriental and Electric Company, £1 shares	11s.	⅛-¼
Southampton Electric Company	—	—
St. James's and Pall Mall, Ordinary	5	6¼-6¾
—— 7 per cent. Pref.	5	8-8½
Swan United	—	—
Telegraph Construction and Maintenance	12	38-40
—— 5 per cent. Bonds	100	—
Westminster Electric Supply, Ordinary	5	5⅜-6⅛
Yorkshire House-to-House	4½	4¼-4½

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NOTES.

The Latest Diversion.—Gambling through the telephone.

Siam.—The electric tramway at Bangkok is being extended.

Limoges.—This town will shortly be lighted by electricity.

The Antwerp Exhibition.—This exhibition is to be opened on the 5th proximo.

The Cance Arc Lamp.—Various improvements have been effected in the Cance arc lamp.

Camberwell.—Mr. Morgan declares that Peckham can be lighted by electricity without touching the rates.

Kaiserslautern.—A site has now been decided upon by the municipal authorities for the central electric light station.

Search-Lights.—On Monday, at Swansea, Mr. John S. Brown demonstrated to a number of people the capabilities of a powerful search-light.

Edinburgh.—New telegraphic and telephonic apparatus is being installed in the new part of the building of the Edinburgh General Post Office.

Electric Illumination.—The concluding lecture on this subject was delivered by Prof. J. A. Fleming before the Royal Institution on Tuesday.

Athletics.—The Electric Athletic Association, in connection with the Central Telegraph Office, held a conversazione at the Holborn Town Hall last week.

The Late Frankfort Exhibition.—The long-delayed report of the Testing Committee of the Electrical Exhibition held at Frankfort on-the Maine in 1891 has now been issued.

Newport Tramways.—The Newport Town Council decided on Tuesday to purchase the local tramways. It is to be hoped that the Municipality will adopt electric traction.

Paris Electrical Testing Laboratory.—A table of the rates charged for testing different instruments appears in the current issue of the *Bulletin International de l'Electricité.*

Paris.—The engineering works of M. de Méritens, in the Rue Boursault, Paris, are about to pass into the possession of M. Saillard, who will supply electric light in several adjoining streets.

A Freight Railway.—The Common Council of New Haven, Conn., have decided in favour of an electric freight railway to traverse the city streets and carry freight to manufacturing establishments.

Crystal Palace School of Engineering.—Sir Edward H. Carbutt presented on Saturday the certificates gained by students of the Crystal Palace School of Engineering during the Easter term.

Lighting of Mines.—A paper dealing with the electric lighting of mines was read last week by Mr. F. Brown before the South Staffordshire branch of the National Association of Colliery Managers.

The Telephone Supersedes the "Tickers."—The removal of "tickers" from the offices of outside brokers has led to the substitution of the telephone between in one case a member of the Exchange and a bucket shop.

Telephony.—An extension of the telephone system is to be made from Weston-super-Mare to Bridgwater and Taunton. Telephonic communication has just been established on the railway between Crieff and Comrie.

The Fleecing of Inventors.—We are glad to see that the *Pall Mall Gazette* has now started a crusade against the swindling policy pursued by some patent agents. Let the scroll be unrolled and show prominently how inventors are fleeced.

Tuscany.—Two concessions for the introduction of the electric light in Pratovecchio and Stia have been granted by the local authorities to Mr. Nardi. The alternating-current system is to be adopted, and alternators of Italian design will be used.

Telephony in Christiania.—According to the annual report of the Christiania Telephone Company, the number of subscribers at the end of 1893 was 3,774 with 4,235 instruments, as compared with 3,287 and 3,620 respectively at the end of the preceding year.

Report on the Hermite System.—Copies of the report on the experiments made with the Hermite system at Brest, and to which reference was made in our last issue, may be obtained of Messrs. E. and F. N. Spon, 125, Strand, W.C., at the price of sixpence each.

Royal Institution.—On Thursday next, the 3rd prox., Prof. Dewar will deliver the first part of a course of lectures at the Royal Institution on "The Solid and Liquid States of Matter," and on Saturday, May 5, Captain Abney will begin a course of lectures on "Colour Vision."

Lighting of Railway Stations.—The electric lighting of railway stations in Prussia has made good progress. The total number of lamps at such installations amounts now to 2,772 arc lamps and 11,261 incandescent lamps. Most of these stations have their own plant.

Milan.—The Società Generale di Elettricità had 33,080 incandescent lamps connected to their mains in December last, as compared with 25,490 in the corresponding period of the previous year. In addition to these, the company supply the current for working the electric tramway.

Electrical Trades Section.—A meeting of the Electrical Trades Section of the London Chamber of Commerce will be held at Botolph House, Eastcheap, on Friday next, the 4th May, at 2.30 p.m., to consider the Locomotive Acts in relation to the traction industry.

The Glasgow Central Station.—The current number of the *Transactions* of the Institution of Engineers and Shipbuilders contains, among other information, the paper read recently before that institution by Mr. Wm. Arnot, A.M.I.C.E., on "The Corporation Electric Light Supply."

Lyons.—A proposal has been submitted to the exhibition authorities by M. Claret for the electric lighting of the grounds and the Grand Cupola on condition of being allowed to issue tickets for admission to the Cupola and the Palais des Beaux Arts. The matter is under consideration.

James Forrest Lecture.—The council of the Institution of Civil Engineers announce that on Thursday next, May 3rd, the second lecture of the James Forrest series will be delivered by Dr. John Hopkinson, F.R.S., M.I.C.E., whose subject is "The Relation of Mathematics to Engineering."

French Union of Electrical Workers.—The Chambre Syndicale des Ouvriers Electriciens is making efforts to get all the electrical workmen to join its ranks. A register of vacancies is kept, and among other objects is the keeping up of the standard of wages and the insurance against accidents.

Electrical Communication with Lightships.—Earl Spencer, speaking the other day, remarked, in con-

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nection with the recent report of the Royal Commission on this subject, that they might hope soon there would not be a single spot on the coast where such communication had not been effected.

Students of the Institution.—A students' meeting of the Institution of Electrical Engineers will be held on Friday next, the 4th May, at 28, Victoria-street, S.W. Mr. F. Digby Latimer will read a paper, entitled "A Description of the Electrical Type-printing Instruments as used by the Exchange Telegraph Company."

Coxeyites on the Cars.—The Coxeyites, the labour army of Mr. Coxey, captured a number of electric cars south of Omaha a few days ago. So runs a Press message from New York. The telegram does not state whether they caught anything else, as, for instance, a shock sufficient to knock them into a cocked hat.

A Large Electric Railway Scheme.—An article of incorporation has been filed for the Central Jersey Traction Company, which is to develop the electrical scheme devised by Joseph H. Realls, of New York, who expects to connect New York and Philadelphia and all the intermediate points by a trolley system.

Milan.—Messrs. G. Robecchi, de Zeme Lomellina, and Mario Azari have drawn up a scheme for the electric transmission of power to Milan. The power available in the Toce Valley from two waterfalls amounts to 57,000 h.p. Of this, it is proposed to transmit 22,500 h.p. to Milan. The total cost is estimated at £640,000.

Prompt Statistics!—The United States census department have now issued figures relating to the electrical industries in the State of New York They are based on returns made for the year ended May 31, 1890, and are of course of no value whatever in throwing light upon existing circumstances in the electrical trades.

City of London.—The returns published in another column show the progress which the City of London Electric Lighting Company is making. A noteworthy feature in this connection is the fact that the company intend in future to publish similar returns every quarter, an example which might well be followed by other supply companies.

The South Staffordshire Tramways Action.—A satisfactory conclusion to this action, which was detailed in our last issue, and the decision of which we give this week, has been arrived at. The conclusion is the issue of a *stet processus*. Those who do not understand this phrase will find the definition of it in ——'s dictionary. It means ——.

Destructive Effect of Electrical Currents on Subterranean Metal Pipes.—We have received an advance copy of a paper on this subject by Mr. Isaiah H. Farnham, which was to be read at a meeting of the American Institute of Electrical Engineers. The question is a very important one, and we hope to reproduce the paper in an early issue.

The Eight Hours' Day.—A pamphlet on "The Eight Hours' Day in British Engineering Industries," by Mr. J. Stephen Jeans, has just been published by Messrs. Ballantyne, Hanson, and Co., of Tavistock-street, W.C. The *brochure* has special reference to the recent report of Messrs. Mather and Platt, some of the details of which were given in a previous issue.

Protection of Workmen Against Accidents.—A new law is about to be set in operation in France for the protection of workmen against accidents. With regard to steam, gas, electric, and hydraulic motors, it is stipulated that they shall only be accessible to those persons who have to attend to them, and that the starting and stopping of any motor must always be preceded by a signal previously agreed upon.

Visit to University College.—This (Friday) evening, at 7.30 p.m., the members of the Junior Engineering Society will visit the new mechanical and electrical engineering laboratories at University College, Gower-street, W.C. The visitors will be under the guidance of Prof. T. Hudson Beare and Prof. A. J. Fleming, who have arranged special demonstrations in connection with the various machines.

A Railway up the Jungfrau.—Another scheme for the construction of an electric railway to the summit of the Jungfrau has been laid before the Berne Conseil d'Etat, the projector this time being Mr. Guzer Zeller, of Zurich. Starting from Scheidegg, the highest point of the Wengeralp railway, the line is to ascend to the Eiger Glacier, the Eiger, and the Mönch. The summit of the Jungfrau will be reached by an elevator.

Lighting of the Baltic Canal.—It is intended to light by electricity the Baltic Canal, by means of 25,000 incandescent lamps arranged on the two banks of the canal. Each lock will, in addition, be illuminated by 12 arc lamps, and electric lamps will also be used for signalling purposes. This installation is to be set in operation next year. The generating plant will be placed in buildings constructed at Holtenau and at Brunsbüttel.

Storage Batteries.—In a paper on "Central-Station Lighting," which has been read by Mr. Pedro G. Salom before the Franklin Institute, he advocates the employment of storage batteries in central-station lighting on the grounds that they effect a substantial saving in operating expenses; that they increase the factor of safety; and that they permit of a material extension of distribution without increasing the size of the power plant.

"Clay Pigeons" and Electrics.—We fail to see any connection between "clay pigeons" and electrics; but the Herculite and Electrical Manufacturing Company, Limited, of Bower-road, Hackney Wick, evidently know the difference. The company has been mulcted to the extent of 20s. fine and £5. 5s. costs for selling as "clay pigeons" pigeons made of a bituminous composition. We would suggest that the company should shoot the "clay pigeons" and keep the electrics alive.

O.S.A. Smoking Concert.—A smoking concert of the Old Students of the City and Guilds of London Institute will take place on Friday next, May 4, at Mason's Hall Tavern, Mason's-avenue, Basinghall-street. Mr. T. E. Gatehouse will play the violin, Mr. Thos. H. Harrison will sing, and many other able performers have promised to assist. It is to be hoped, as it is some time since the last social meeting of this kind was held, that the members of the O.S.A. will gather in large numbers.

Lectures.—The sixth of the series of lectures arranged by the executive of the Wigan and District Mining and Technical School was delivered last week by Mr. G. S. Corlett, A.M.I.E.E., on "The Application of Electricity to Mining Operations." The last lecture of the course on "Electrical Engineering" was given on Monday at the Central Higher School, Sheffield, by Mr. T. Scott Anderson. The lecturer clearly described the various methods of electric welding and their chief applications.

Society of Arts.—On Monday, at 8 p.m., the first Cantor lecture on "Typewriting Machines," by Mr. H. C. Jenkins, A.M.I.C.E., will be delivered. The lecture will deal with writing and printing machines, machines at the 1851 Exhibition for the use of the blind, elementary forms of typewriters, and early attempts to construct practical machines by Hughes, Wheatstone, Foucault, Beach, and

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others. On Wednesday, at 8 p.m., a paper on "Nickel," by Mr. A. G. Charleton, A.R.S.M., will be read.

The Explosion at Nantes.—With regard to the recent explosion at Nantes, referred to in our issue of the 6th inst., a French contemporary states that this incident again shows the necessity of some control being exercised over installations in course of being carried out and during the working of stations. The question of a municipal control in Paris has been recently discussed, and the journal in question asks whether fresh accidents are to be awaited before some such organisation is constituted.

Frankfort-on-the-Maine.—Good progress is being made with the municipal central electric light station. The machinery house is to be completed by the end of June. It is hoped that the installation will be at work on the anniversary of the day when the local authorities authorised the project, which will fall on October 12 of the present year. For the first lighting section which is to be taken in hand, applications have been received equivalent to 25,000 lamps. They include a number of applications for motors.

The Clontarf Electric Tramway.—At a recent meeting of the Commissioners, held in the new Town Hall, Clontarf, Mr. Antony O'Connor and Mr. S. G. Frazer appeared as a deputation to seek the Commissioners' sanction to a proposed electric tramway between Clontarf and the Hill of Howth, to be laid down by the Clontarf and Hill of Howth Tramway Company, Limited. The secretary has been instructed to communicate with Lord Ardelaun, as the proposed tramway would go over his property.

Electrical Exhibition in Paris.—It is proposed to hold an electrical exhibition in Paris next year from July 1 to October 31, using for the purpose the machinery hall at the Champ-de-Mars and the Palace of Industry at the Champs-Elysées. In the former there are to be installed steam-engines and dynamos for the transmission of power, while the latter will be devoted to electromotors and all applications of electricity. The two buildings are to be connected by electric tramways, where different systems of electric traction will be shown. Electric boats will also run on the Seine.

South Africa.—A congress of the chambers of commerce throughout the whole of South Africa sitting at Cape Town has passed a resolution advocating a reduction in the cable rates to Great Britain. Mr. Jagger, the mover of the resolution, said that the Eastern Telegraph Company derived £120,000 a year from South Africa, and that they could reduce their charges and yet leave themselves a handsome profit. It was resolved that the subsidies ought to be rearranged, so that all the South African Governments might join in them, and might renew their contracts on a basis of reduced charges.

The Chemnitz Station.—The first scheme for the central electric light station which is being erected here by Messrs. Siemens and Halske, was arranged for 5,000 16-c.p. lamps in operation simultaneously, and the work was to be carried out so as to have mains laid down for the supply of 10,000 lamps. However, the demand has been so great that already, before the work has been completed, further powers have been asked for. Applications have been received for 8,750 incandescent lamps, 248 arc lamps, and electromotors to the extent of 194 h.p. The applications are equivalent to 13,250 16-c.p. lamps.

The "Electrical Review" v. Harness and others. Messrs. Alabaster, Gatehouse, and Kempt, the proprietors of the *Electrical Review*, have this week endeavoured to secure from Mr. Harness and others the costs, amounting to £596, incurred by them in defending, which they did successfully, the action brought by Dr. Tibbits against them. The action, which was heard before Mr. Justice Hawkins and a special jury in the Queen's Bench Division, was brought for "maintenance." After evidence had been given, the jury was discharged, and the case now stands over for legal argument as to whether "maintenance" could be made out upon the evidence offered.

Electrical Conductivity of Some Solutions of Salts.—Mr. A. C. MacGregory in the *Ann. Phys. Chem.* has determined the conductivities of solutions of calcium chloride, nitrate, sulphate, and acetate; strontium chloride, nitrate, and acetate; barium and silver acetates; and potassium oxalate. The results are given in tabular and curve form. The curves for the molecular conductivities are, in general, of a perfectly regular character, and show little tendency, even with the most dilute solutions, to a departure from their usually rectilineal character. Silver acetate shows, however, a change in curvature in dilute solutions, for which no cause can as yet be assigned.

The Beto Noire of Electric Supply Companies.—One of the bugbears of electric supply companies is the liability of actions being brought against them on account of vibration set up in buildings adjoining the generating stations. Several cases have already been before the Courts, and now, as recorded in our legal columns, the City of London Company have had their turn. It was hardly to be expected that such an unreasonable request as an injunction would be granted against a company working under statutory powers of this kind, and the plaintiffs are fortunate in being entitled to enquiries as to the damages caused, etc. At the same time, is there no effectual means that can be adopted to overcome vibration so as to remove this *bête noire* from our midst?

Self-Oiling and Filtering Pedestal.—A new self-oiling and filtering pedestal is being introduced by Messrs. Straker, Whitworth, and Co., of 139, Cannon-street, E.C. The appliance, which has been devised by Mr. Straker, is applicable to spindles and shafts rotating at from 150 to 10,000 revolutions a minute. The oiler is a continuous circulator, and is embodied in the design of machinery bearings. It can be attached to existing machinery or employed in the form of a self-contained pedestal. We are informed that these pedestals are being constructed under license by Messrs. Siemens Bros. and Co., the Electrical Construction Company, and other firms, for dynamos, motors, and shafting, and that a large number of them are already at work on other types of high-speed machinery. It is claimed that the pedestal will work efficiently for months without replenishing or requiring any attention.

Electric Bells.—We have received from the General Electric Company, Limited, 71, Queen Victoria-street, the tenth edition of their electric bell and general catalogue. Among the contents are descriptions of bells for houses, stables, mining, signalling, fire-alarm circuits, and various sets of bells, improvements in which have been made. Holden's repeaters for electric bells have been remodelled by the original inventor. A large variety of pushes is illustrated, including all-china pushes. A considerable amount of space is devoted to batteries, which are illustrated in all their different parts. Among them are the E.C.C. dry cells. Fans driven by Edison-Lalande cells are also detailed. Among electric gas-lighters there have been introduced, in addition to the usual form, a new type specially adapted for lighting gas-stoves, and also lighters with bent spires for window lights where inflammable articles are on show. As an appendix there are given a few notes on the application of electricity, instructions for fitting and connecting electric bells, and diagrams

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showing the usual ways of connecting up electric bells, indicators, etc.

Lighting in Berlin.—A report of the Berliner Elektricitäts Werke gives figures of the working of the company up to June, 1893. The number of lamps 30-watt) increased from 272,000 to 325,000 in the past year. The following is a table of the consumption in kilowatt-hours since 1885 :

	Private lighting.	Street lighting.	Electric motors.
1885 (Aug. 13 to Dec. 31)...	38,150	—	—
1886	303,120	3,094	—
1887-8.....	715,920	6,282	—
1888-9.....	1,173,780	19,962	12,956
1889-90	2,511,000	21,666	69,591
1890-91	3,554,000	21,884	274,457
1891-92	4,831,440	21,708	186,611
1892-93	5,228,600	21,776	238,042

There are now 232 electromotors in use of a total of 785 h.p. The net profit on last year's working was £54,470.

Lighting of the Embankment.—The Highways Committee of the London County Council reported on Tuesday that the Council on the 10th inst. instructed them to consider the advisability of widening the footways of the Victoria-embankment by taking in a few feet of the carriageway on each side, in order to allow the electric light standards to be placed on the sides of the carriageway without interfering with the trees. With reference to this suggestion the committee pointed out that the footways are of great width, 20ft. on the river side and 16ft. on the other, and in order that the lamp standards might be clear of the trees the width of each of the footways would have to be increased by 8ft., and that of the carriageway correspondingly reduced from 64ft. to 48ft. Having regard to all the circumstances, they were of opinion that it was not advisable that the course indicated in the reference should be adopted. They understood that the Parks Committee had now under consideration a suggestion that some of the trees should be removed to facilitate of the proper growth of the remainder; and they thought it advisable that, until some decision should have been come to upon this suggestion, the further consideration of the question of the positions to be occupied by the lamp standards should be deferred.

Tramway Companies and Electric Traction.—Some time ago it was suggested to the Board of Trade that the regulations and recommendations of the Joint Committee as to the use of electric traction should apply both to past and future legislation. The Board of Trade replied that they were quite prepared to consider the advisability of bringing in a Bill for the purpose of making these regulations retrospective should it be shown there was a consensus of opinion that the tramway world wished that such should be done. The London Chamber of Commerce and the Tramways Institute issued circulars to every corporation and tramway company. The result of the replies showed a want of foresight amongst those responsible for the management of the tramways for the benefit of the shareholders. The tramway companies replied that as they did not contemplate electric traction at the moment, they did not see how the circular applied to them. The few answers received were forwarded to the Board of Trade and the reply was that they considered a sufficient consensus of opinion had not been given to justify them in promoting the Bill. The council of the institute urge the members to pledge themselves to assist in procuring from every tramway company an expressed desire that the Board of Trade will ask for such legislation as is sufficient to make these regulations retrospective in every Act, whether that company contemplate or not the adoption of electric traction now or in the future.

Lighting of Poplar.—A report has been presented to the Poplar District Board by Mr. W. H. Preece with reference to the electric lighting of the area under their jurisdiction. Mr. Preece is in favour of electric lighting being supplied by municipal authorities direct, chiefly on the ground of economy, and because lighting is essentially a part of the duty of a sanitary authority. He says that the City is lighted by a private company, and the user has to pay 8d. per supply unit as against 6d. in St. Pancras, where the energy is supplied by the local authority. He further points out that the Corporation have entered into a contract for 21 years to have electric light supplied to their tenants in their markets at the same price as they have hitherto paid for gas. The Commissioners of Sewers are paying the electric lighting company £27 per annum for each arc lamp, but if they had generated their own light and done the work themselves, it would not have cost them more than £17 per annum each arc lamp. From this and other circumstances he draws a conclusion that, as the proper illumination of the streets is the function of the local authority, the Poplar Board should erect their own machinery and supply the light, for which purpose they have obtained a provisional order. The report is being printed for circulation, and an important discussion is to take place when this has been done. It is estimated that a capital of £30,000 will be sufficient for the first requirements of the Poplar district.

The Connelly Motor.—We note the formation of the Tramway Motor Company, Limited, to work the Connelly gas or oil motor for tramway traction. The prospectus quotes the cost of haulage by the different systems used on the lines of the Birmingham Central Tramways Company, but it omits to state the cost per mile run with the Connelly motor. The company assert that their motors "supply the cheap and at the same time effective haulage so greatly needed, and so long desired by all those interested in tramway companies." It would be interesting to learn some definite figures on this point. If the average cost of horse traction is assumed to be 6d. per car mile run, what is that of the Connelly motor? Intending investors in the company should ascertain information on this matter, as unless the company can prove to tramway companies that by the adoption of the motor a saving will be effected over their existing methods, there will be no inducement for the latter to adopt the system. Moreover, the Connelly motor has been before the public for some years, and, as far as we know, no tramway company has taken it up. Apart from this, the company are closing the subscription lists before the investing public has an opportunity of seeing the opinions of the technical Press on the prospects of the system, and are relying upon the statements made by the daily papers, which are entirely incompetent to decide the question as to the capabilities of the motor. It must also be borne in mind that electric traction on the trolley system has been demonstrated to be the best and cheapest yet introduced, and as the Board of Trade has now paved the way for its development, this method should now take the lead in this country.

The Proposed Pacific Cable.—Public opinion in the Australian colonies in favour of the proposed Pacific cable is growing in strength. It is felt, a *Times* correspondent remarks, that sooner or later the cable will have to be constructed, possibly under conditions which may be less favourable to the colonies and Great Britain than the cable now proposed, which would only touch British territory and would be controlled by British influence. In this connection Mr. G. Seymour, M.I.C.E., writes to an evening

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paper, giving figures which show that the existing lines with which, directly or indirectly, the Pacific cable would have to compete, are in receipt of subsidies and guarantees amounting to a total of £227,179 per annum. Thus it would appear that to place the Pacific cable project on the same footing as the existing companies, this project should in common fairness be aided by the Governments interested in it, and who have so heavily handicapped any scheme which might compete with the existing telegraph lines. From another source we learn from Ottawa that the prospects of the Inter-Colonial Conference to be held there in June are very encouraging. Already Victoria, Queensland, South Australia, and New Zealand have agreed to be represented. As to the mother country, Lord Rosebery's promise of Downing-street representation will be remembered. That the colonies mean business is seen from the fact that Victoria proposes to send a deputation of five gentlemen. When Sir Thomas M'Ilwraith, Mr. Reid, and Mr. Huddart have concluded their labours in London, and the conference has been held, everyone will hope that it will only remain for the orders to be given out for the trans-Pacific cable and the new steamships of the "Imperial" Line.

Comparative Experiments on the E.M.F. of the Clark Standard Cell.—Mr. K. Kahle details in the *Ann. Phys. Chem.* experiments made with the object of ascertaining the effects which change of form, purity of material, age, and temperature have on the E.M.F. of the Clark standard cell. The H-form devised by Lord Rayleigh, the form proposed by Feussner, and that adopted by the Board of Trade were compared with one another. The results show that the H-cell is far superior to the other two, both in the ease with which it can at any time be reproduced of constant E.M.F. and in the fact that impurities and disturbing influences have less effect on its constancy, so that the variation of its E.M.F. from the normal value can with little difficulty be reduced to 0·0001 volt. Greater changes than this were not observed in cells which were often compared with one another during the course of 1½ years. In the effect which temperature has on this cell, it is also to be placed before the others. The author finds that a knowledge of the temperature coefficients of the Feussner and Board of Trade cells is misleading, as the E.M.F. calculated by their means does not agree with that actually observed. On the other hand, as long as sudden changes of temperature are avoided, the value of the E.M.F. for the H-cell can be calculated for different temperatures to within 0·0001 volt, and even with sudden temperature changes to within 0·001 volt. The coefficient for temperatures between 10deg. and 30deg. was found to be $-0{\cdot}000814 - 0{\cdot}000007\ (t - 15)$. The constancy discovered in the E.M.F. of the above form of the Clark standard cell leads the author to propose its adoption for the purpose of defining the unit of E.M.F. He condemns the form of cell adopted by the Board of Trade as not sufficiently fulfilling the requirements of a standard.

Lubricants and their Use.—At the last meeting of the Junior Engineering Society, held at the Westminster Palace Hotel on 13th inst., a paper on "Lubricants, their Use, Testing, and Analysis," was read by Mr. W. F. E. Seymour, of Swindon. The necessity of efficient lubrication and importance of being able to judge the utility of various lubricants for different kinds of work was first pointed out. Lubricants might be classed into solids, semi-solids, and liquids. The composition of vegetable, land, animal, fish, and mineral oils was considered, and their proper applications referred to. The author next gave an extended account of the more important lubricants—tallow, rape, olive, and castor oils—and detailed the uses to which they were each best adapted. Of mechanical testing appliances, Ingram and Stapfer's oil-tester and Thurston's machine were illustrated, and the mode of working and of recording the results were shown. The suitability of a lubricant for any particular duty could be judged by its viscosity and specific gravity, in the determination of which various forms of instruments were employed. The principal viscounters used were Beverton, Redwood's, and Sackar's; these were described, and the process of working with them explained. Passing on to chemical analysis, the methods adopted for the determinations of free acid, drying properties, flashing point, mineral matter, congealing point, total fatty acids, mineral oil, or unsaponifiable matter, were given. An appendix to the paper was devoted to Maumené's test, Pontet's claidix test, Valenta's acetic acid test, Dalican's method for congealing-point of tallow, and Gray's flash-point apparatus. In illustration of the paper, specimens of the various oils were shown for examination, and there were also a number of instruments exhibited which had been lent by Messrs. Baird and Tatlock. The proceedings closed with the announcement of the ensuing meeting on May 11, when a paper on "Engineering Experience at Sea" will be read by Mr. J. Lane, chief engineer, and Mr. J. Hawthorn, extra chief engineer, M.I.Mar.E.

Chicago Exhibition Awards.—The Royal Commission have issued a list of the awards to English exhibitors as received from America. In many instances it appears to differ from the lists issued from time to time at Chicago as the awards were made by the judges. Many of the entries refer to exhibits which did not form part of the British section. Each award consists of a bronze medal and a diploma. All awards are of equal value. The medals and diplomas will be forwarded to the exhibitors as soon as they are received by the Royal Commission. It is not anticipated that they can be ready for issue for a long time to come. In "Department F, Machinery," under Group 69, motors and apparatus for the generation and transmission of power, hydraulic and pneumatic apparatus, the following are among the awards made: Messrs. Galloways, Limited, Manchester, engine; Messrs. Richard Hornsby and Sons, Limited, Grantham, oil-engine; Mr. David Joy, Westminster, model of the Joy valve gears; and Messrs. Willans and Robinson, Limited, Thames Ditton, Surrey, Willans compound central-valve engine and Siemens dynamo combined. In "Department G, Transportation," Messrs. John Brown and Co., Limited, Sheffield, have received an award for an exhibit which included electro-coated shafting for steam vessels. In "Department J, Electricity," the following awards have been made: Group 123.—Apparatus for electrical measurements: Mr. James White, Glasgow, electromagnetic balances, "Kelvin." Group 124.—Electrical batteries, primary and secondary: The Epstein Electric Accumulator Company, Limited, London, storage batteries. Group 126.—Transmission and regulation of the electrical current: General Electric Company, Limited, high-insulation switches, and other incandescent house fittings. Group 133.—Electric telegraph and electric signals: British Government Postal Telegraph Department, London, collection of modern telegraphic apparatus. Group 137.—History and statistics of electrical invention: British Government, Postal Telegraph Department, London, historical telegraphic apparatus; Corporation of Birmingham, Birmingham, original Woolwich dynamo; and Group 138.—Progress and development in electrical science and construction, as illustrated by drawings and models of various countries: General Electric Company, Limited, London, carbons for arc lamps.

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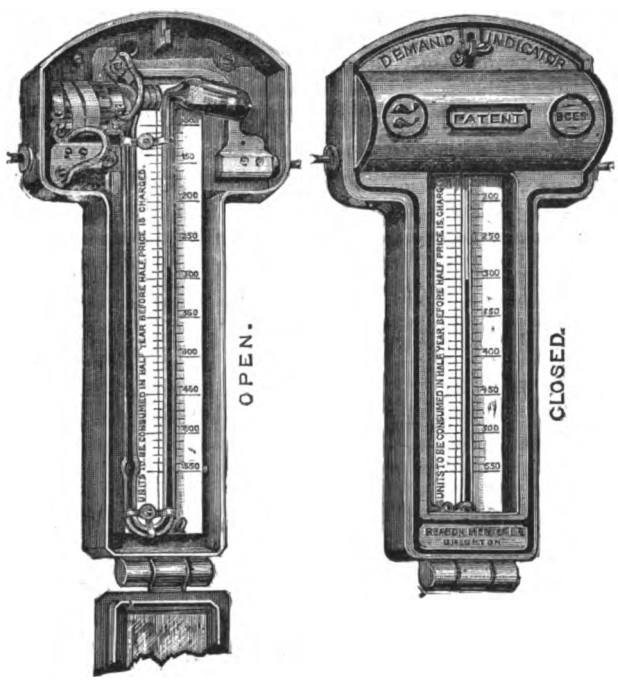
ELECTRICITY METERS.*

BY R. P. WILSON.

(Concluded from page 457.)

In conclusion, the most important and least appreciated meter at present on the market has been invented by Mr. Arthur Wright, of Brighton—viz., the maximum demand meter. A supply of electricity is not similar to a supply of gas, for the reason that the latter may be always produced under the most favourable conditions, whereas in the case of the electric light the maximum output required at any given time is a measure of the plant required in the central station. In view of the fact that electric light companies are not philanthropic institutions, it is evident that the most important duty of a central-station engineer is to make a profit. This can only be done by encouraging such customers as have a large consumption and a small number of lamps. Very many systems have been introduced from time to time to popularise the use of electricity, but the only one which produces the desirable customer is the method adopted by Mr. Wright—*i.e.*, to encourage a large consumption and diminish the maximum demand at any one time. This he has succeeded in doing by his method of charging at Brighton, which is as follows: The "maximum demand" meter is fixed in each customer's



Wright's Maximum Demand Meter.

premises, and registers the total amperes required at any one time during the quarter. After a certain number of watts have been used during the quarter (corresponding to this maximum demand, for two hours a day) all further current supplied is charged at half price, so that consumers have every inducement to increase their consumption by putting lamps all over the house, and they also have every inducement to minimise the number of lights turned on at any one time. As Mr. Magden points out, a customer having 10 lamps burning 10 hours a day only requires plant for 10 lamps that burn the same amount of light as a man who has 100 lamps which he burns for one hour, whereas the man with the 100 lamps requires 10 times as much plant and to all intents and purposes the same standing charges.

The meter itself consists of a U-shaped tube filled with a suitable liquid having a bulb at each end, one of which is surrounded by a coil in series with the ordinary meter, the other being bent down to form a trap. The current passing through the series coil heats, and therefore expands the air contained in the bulb it surrounds, and forces the liquid into the bulb at the other end; the quantity of liquid thus caused to overflow diminishes the height of the liquid standing in the right-hand tube, and thus gives a registration of the maximum demand this particular customer has made on the plant at the station during the quarter.

The following are examples of scales showing different methods of benefiting long-hour consumers, and thus encouraging profitable business. The first is the Brighton scale, and its great simplicity will at once be apparent. Current is supplied at 115 volts.

Maximum demand. Amperes. Instrument tube holding registering fluid.	Number of units to be consumed in half-year at 7d. All surplus at 3½d.
1	= 42 units.
2	= 84 units.
3	= 126 units.
4	= 168 units.
5	= 210 units.
6	= 252 units.
7	= 294 units.
8	= 336 units.
9	= 378 units.
10	= 420 units.

Example.—A customer's consumption in the half-year amounts to, say, 564 units, his indicated demand being eight amperes. He will then pay as follows:

336 units at 7d. =	£9	16	0
228 units at 3½d. =	3	6	6
564	£13	2	6

The next is a scale that has been tabulated for a company that has hitherto given discount proportional to the amount of the account, regardless of the actual maximum number of lamps in use at any time. Should the customer's consumption at the indicated demand not reach the figures in the first column, he is charged full price. Should the consumption exceed the figures in the first column, but not exceed those of the second column, he is to receive 5 per cent. discount off his account. Should this consumption range between the second and third columns, he receives 10 per cent. discount; if between the third and fourth, 15 per cent., and so on.

The basis of the different discounts is as follows:

5 per cent. when consumption equals customer's maximum demand for 700 hours in the year.
10 " " " 1,000 " "
15 " " " 1,200 " "
20 " " " 1,500 " "
25 " " " 1,800 " "
Voltage, 110.

Maximum demand. Amperes. Instrument tube holding registering fluid.	Discounts. 5%	10%	15%	20%	25%
	When following minimum quantities are consumed.				
1	77	110	132	165	198
2	154	220	264	330	396
3	231	330	396	495	594
4	308	440	528	660	792
5	385	550	660	825	990

Example.—If a customer consumes in the whole year 960 units at a maximum demand of five amperes, he is entitled to a discount of 20 per cent., which, at 8d. per unit, works out as follows:

960 units at 8d.	£32	0	0
20 per cent. discount	6	8	0
	£25	12	0

The discount for the year is in this case deducted from the customer's bill at Christmas, that being the darkest quarter, and also ending the financial year. The scale of discounts last given may be modified so as to offer a rapidly-rising bounty to long-hour consumers especially, but considerations of space will not now admit a fuller reference to this arrangement. The same reasons have curtailed the scales here described, but obviously they may be extended as desired. One thing of exceeding importance has been demonstrated—viz., that reductions in price on the basis of the foregoing scales will induce customers to wire their buildings more thoroughly, thus giving the works a long and profitable load, while the consumer obtains current at a sufficiently moderate price to efficiently compete with gas. Where motors are used, the instrument is equally useful, as the customer reaps the benefit of a long-hour load by getting a liberal discount off his whole bill.

There are, of course, very many other features in the meters referred to in this paper that deserve notice, but

* Paper read before the Northern Society of Electrical Engineers, April 9, 1894.

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the limited time available has of necessity rendered this paper very incomplete. The author hopes, however, that it possesses some points of interest to members of this society.

DISCUSSION.

Mr. Wordingham: Mr. Wilson referred to a maximum demand meter of Mr. Wright. A thing of that kind is wanted. We certainly want it in this city, where we have a special method of charging. We charge now by the number of lamps connected. There is another maximum demand meter. It is made by Messrs. Nalder Bros., and is simply an ampere-meter with a horizontal needle, which pushes forward an aluminium pointer. I understand there is a certain amount of drop in voltage in Mr. Wright's meter. I should like to know what the drop is if Mr. Wilson can tell me. In the Chamberlain-Hookham meter Mr. Wilson mentions a very ingenious device for reducing the friction of the rotating disc. It certainly is ingenious, but it was invented by Ferranti. Mr. Wilson mentioned the Thomson meter. He says it has been used for five wires. There have not been very many made, I understand. We have one working here. It has been working for about five months. I have not any means of testing it, but judging from the weekly readings and the estimated consumption, it seems to be going very well indeed. Another point mentioned by Mr. Wilson with regard to the Thomson meters was that they now allow the shunt current to go through the main coil, whereas in the earlier instruments they had a subsidiary coil. The shunt winding and the armature together form a motor independent of the current through the lamps—the object being to overcome the initial friction. If the pressure rises above the normal, this may be more than just compensated for, and the meter will go without any current. There is one point worth mentioning. In testing watt-hour meters, you must either cheat the consumer or the company. Of course, what the consumer should pay for is the current through his lamps multiplied by the pressure at the lamps. Now, if the shunt winding be connected on the main side of the meter, the company is supplying a higher pressure than they get paid for. If, on the other hand, the shunt winding is connected to the consumer's side of the meter, the consumer pays for the current used in the shunt coil of the meter, which is, of course, no benefit to him. In the picture of the five-wire the current only reverses on the three inners, never on the two outers.

Mr. F. F. Bennett: It would have been interesting if Mr. Wilson had mentioned the amount of current passing through the shunt of the Thomson and other meters. Some time ago I made a test of the different shunt meters—viz., the Frager, Thomson, Reckenzaun, etc.—and I found the average current absorbed equal to about 10 milliamperes. If there were 1,000 such meters installed in a town, the current absorbed by the shunt would be equal to one Board of Trade unit per hour, and as there are 8,736 hours in the year, that number of Board of Trade units would be wasted, the total exceeding 11,000 electrical horse-power hours. This I consider a very substantial objection to the shunt meters. In the case of connecting a shunt meter up so that the meter would register the amount of current passing through, as has been suggested, it would be rather unpleasant for a consumer who went away for three months, and on his return found that a bill was charged against him, but knowing all the time that a single light had not been used during that period. It would be lowering the electric meter to the level of the gas-meter, which, to say the least, would be degrading to the former. Mr. Wilson made reference to Aron meters; I have had rather considerable experience with this meter, and I cannot say it is satisfactory. There are several objections: its fine clockwork and frail delicate outer case make it thoroughly unsuitable for a wet or damp cellar; the necessity of winding the two clocks up every month, and if one clock were to stop all record was lost; and it is a matter of a consumer owing the company a large bill, or the company owing the consumer, depending entirely upon which clock stopped. Another difficulty is the matter of adjustment or synchronising, and even when you have taken trouble daily for four or five weeks in the test-room to get a nice adjustment, on removing the pendulums, so that the meter may be transferred to the consumer's premises, it was often found that further labour in synchronising was required. In Preston a consumer objected to pay his bill, stating that his meter, which was an Aron, was registering when no lights were being used (he had listened and heard the clocks going). To convince the consumer that the meter was correct, I put in a Ferranti meter to check it, and there was not a 5 per cent. difference in the registration at the end of the month. The solicitor for the consumer, when I told him of this, said it was like "setting a thief to catch a thief," but I am glad to say the company got the verdict. The Ferranti meter is not without its faults. On several occasions I have found that it would not start with only an 8-c.p. lamp in circuit, and in some cases would not start where a single 16-c.p. lamp was only in circuit. I have made a careful test of all the meters, and I must say, without prejudice, that for compactness, accuracy, durability, and imperviousness to damp or wet, the Ferranti meter certainly takes first place.

Mr. Madgen: The order in which the various types of meters are placed to represent the extent to which they are respectively in use, may give rise to misconception. It is all very well as a matter of historical interest, but the point of commercial interest is the meters which are being put in to-day. Mr. Wilson wished to avoid the historical element, but we find him giving first place to the Aron meter—a form which is not now being fixed in any number to speak of. The Thomson-Houston meter, indeed, which he places second on the list, is, I believe, more in favour, but its wasteful shunt circuit is considered a drawback to its extensive use. The Shallenberger meter has undoubtedly been very extensively used, but it cannot be said that there is any finality in a meter which has only a range of about 35. In almost any town you will find several consumers—and the number is increasing—who have one or two lamps continually burning on landings, staircases, etc. A meter with such a limited range does not register such small consumption, which in the aggregate may amount to a very appreciable percentage of the revenue. The Ferranti meter has stood the test of time, and they are now being put in at the rate of about 500 per month, which is, perhaps, the best practical evidence in regard to them. They are neatly, but very strongly, made, so as to fit them for the trying situations in which meters are frequently placed. It is interesting to note, as Mr. Wilson points out, that these meters were the first provided with the double sealing arrangement suggested by the Board of Trade, but previously adopted (and I may add patented) by Mr. Ferranti. I am very glad that Mr. Wilson has so fully appreciated the advantage of Mr. Arthur Wright's demand indicator. The effect of his method of charging for current has shown itself in the results obtained in Brighton during the past year. The load factor improved to 15 per cent., the consumption per lamp fixed had increased, and customers are now being added at the rate of 10 to 15 per week.

Mr. Wilson, in reply, said: In reference to Mr. Wordingham's remarks, I have not seen the maximum demand meter manufactured by Messrs. Nalder Bros., but it is apparently the outcome of the principles evolved by Mr. Wright; but cannot, of course, form an opinion as I have never seen it. His question about the drop in the series coil of Wright's meter I cannot answer, because I do not know what it is. We may, however, assume that it is very small, as Mr. Wright is fully alive to the importance of making it as small as possible, and he undoubtedly knows as much about the subject as we do. With reference to the drop in the series coil of other meters, I think Mr. Wordingham attaches too much importance to this point, as it is in almost all cases so small as to be almost negligible. Mr. Wordingham states that the floating disc which is used in the Chamberlain and Hookham meter was invented by Mr. Ferranti. I had already made the same statement in the course of my paper, although apparently I did not make myself clear. In reference to the Thomson meter, Mr. Wordingham objects to the subsidiary or compounding coil in series with the shunt. Personally, I am at loss to see what objection there can be to this coil. It has not been done away with, as Mr. Wordingham suggests; on the contrary, it is now introduced even into the 5 and 10 ampere meters. In regard to the consumption of the shunt, it has been asked whether this should be paid for by the undertakers or the consumer. It is, of course, apparent that the company must in all cases lose this, as the Board of Trade would never allow the consumer to be charged with it, even assuming the consumer would consent to pay it if they did. Further, the shunt current is used for a specific purpose of overcoming initial friction in any meter. In doing so all its energy is absorbed, and therefore cannot communicate itself to the dials. That the shunt current costs money is important, but the value of any particular meter or meters may be readily ascertained by putting any number of different types that have been tested and found to be accurate in series. The best meter is the one that gives the largest revenue. There is no doubt that those manufacturers who use shunts in their meter are quite alive to the objections raised against them, but they are of opinion that this same shunt has advantages which more than compensate for the annual consumption they involve. Mr. Bennett appears to have been very unfortunate in his experience with Aron meters. There is no doubt foundation for his complaint that they do not invariably synchronise. I have the electric light in my office, and at first, when I went away, I always found I had a bill to pay when I came back, whether I had taken the precaution of taking out the fuses or not. The meter I have now does not do that, and it therefore follows that other meters can be made to behave themselves equally well. The meter, however, does undoubtedly require careful adjustment, but it is nothing more than can be done by a good watchmaker. With reference to Mr. Madgen's remarks, I am sorry to say that his statement to the effect that the resistance of the Thomson shunt is 1,000 ohms is not correct: it is, as a matter of fact, 3,000 ohms. Mr. Madgen has taken exception to the order of importance. I would remind him that the statement referred to is to the effect that the order in which these meters are placed represents approximately the extent to which they are being used (not put in). One of Mr. Ferranti's other representatives agreed with me that this order was correct, and it was not until he had acquiesced that I left it in the paper as it was. In reference to the Shallenberger meter having a range of 1 in 35, I am glad to be able to say that this has been improved, and they now claim to have a range of 1 in 80. The Westinghouse Company are, however, willing to admit that they do not make large meters on this principle, and do not pretend to. The only other point that was raised was about the meter supposed to have been exhibited at the Health Exhibition by Lord Kelvin, but this statement I corrected in reading the paper.

Ship-Lighting.—The new screw ss. "Tantillon Castle," the latest addition to the fleet of the Castle Line, was the first vessel to enter the newly extended graving dock at Blackwall. The steamer is fitted with a complete installation for electric lighting, the current being generated by three dynamos driven by independent engines.

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INSTITUTION OF ELECTRICAL ENGINEERS, Apr. 26.

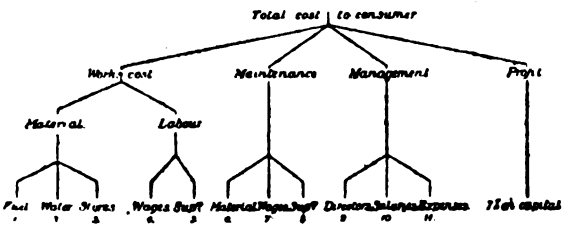
COST OF ELECTRICAL ENERGY.

BY R. E. CROMPTON, M.I.C.E., VICE PRESIDENT.

I address this paper to all who are interested in electrical supply, but especially to the engineers who design and who work electrical supply plant. It is almost exactly six years since I read a paper before this Institution* on this subject, and three years since I read a similar paper before the Institution of Civil Engineers.† I should be glad if those who are really interested in the subject would find time to glance over these two papers after reading the present one, as there is much contained in them which might have been repeated here with advantage if I had not feared to unduly lengthen the paper.

For convenience and brevity I use the word "works" for the whole plant of an electric supply company; such works may have several generating stations. I use throughout the word "energy" for the electrical energy, and I speak of the two well-known systems of distribution as "direct" or "converted" systems. By direct systems I mean all two, three, or other multiple wire systems, with or without storage, in which the energy is supplied direct from the dynamos to the mains, and from the mains to the users without change of pressure. I include amongst converted systems all those in which the energy is either generated at a high pressure, or converted up to a high pressure for transmission through the mains, and afterwards converted to the lower pressure at which it is supplied to the users. In this paper I do not deal with works using water power, but solely with those in which the electrical energy is obtained from fuel. The total cost to the user may be grouped under four heads: works cost, maintenance, management, profit. These may be conveniently sub-divided into 12 sub-heads or divisions, as follows:

TABLE I.



Of these 12 heads I propose to deal at length with 1 to 8 only. The remaining heads of management and profit are outside the province of us engineers, except in one important particular, which is that the interest or profit to be paid on the capital employed is affected by the choice of system used, and by the skill of the designer of the works, so that it is necessary for us to deal with it. Let us assume that our ideal works are designed for the most economical production of 5,000,000 units of energy per annum distributed to users in a large town and under average conditions. We are now in a position to estimate with considerable accuracy that the capital required for the preliminary expenses, for obtaining the requisite parliamentary powers, and for the complete equipment of such works, will not exceed £500,000, or at the rate of 2s. per unit sold per annum. I have arrived at this figure after considerable study of the capital account of existing companies, and of works carried out by local authorities, and I find that it is nearly certain that several existing works will reach this figure as soon as their plant is completed to the scale intended, and worked to the full output; so that, if we consider that entirely new works could now be certainly carried out at a lower cost than that of any existing works, it will be seen that my estimate is on the safe side. Now I think that such works ought to be able to include in the total cost to the consumer such a sum as profit as will yield 7 per cent. per annum on the whole of the loan as well as subscribed capital. In the case of a local authority, a portion of this 7 per cent. would be applied to paying the interest and sinking fund on the original loan, and the remainder would be applied as a profit in the reduction of local burdens or in introducing local improvements; but in the case of a joint-stock company this capital of £500,000 might advantageously consist of £200,000 in ordinary shares, £100,000 in 6 per cent. preference stock, and £200,000 in 4 per cent. debenture stock, so that the average of 7 per cent. on the whole £500,000 might be divided up as follows:

4 per cent. on debenture stock	£8,000
6 per cent. on preference stock	6,000
10½ per cent. on ordinary stock	21,000
Total	£35,000

This sum of £35,000 is equal to a profit of 1·68d. per unit sold. The cost of managing such a company can also be dismissed in a few words. Under this heading it is convenient to group directors' fees, salaries of managing staff and office, meter readers, collectors, all stationery, law, and audit charges, rates, taxes, and insurance. If we take the practice of the best-managed works as a guide, we find that about £8,200 per annum is sufficient to cover all these charges for the largest output that has been yet obtained. It is evident that a sum of £9,000 a year would be an ample one for the management charge on the output of 5,000,000 units. This management charge therefore works out at 0·42 a unit.

You will see, then, that at the scale of working that we are now considering, which is at a scale of output certain to be reached within a year or two by a large number of works, the management and profit items, taken together, should amount to 2·1d. per unit. As I have said above, we engineers have nothing to say in controlling these figures. They are certain to be reached in course of a few years, as it is a mere question of output. The question which I now propose for your consideration is this: What chance have we of reducing the present works cost and maintenance cost included in the sub-heads 1 to 8 to such an extent that the energy may be sold to the public at, possibly, the low figure of 3d. per unit? I believe that Mr. Swinburne has stated that electrical energy, whenever the demand is continuous, such as for certain electrolytic or electrometallurgical processes, can be generated and distributed to short distances at a works and maintenance cost of ¼d. a unit. I believe Mr. Swinburne has good grounds for this estimate, if cheap fuel is available. But for our present purpose, which chiefly concerns the supply of electrical energy used largely for electric lighting, and to a minor degree for power, we cannot fix such a low figure for our ideal works and maintenance cost for the future. Mr. Swinburne's case and those which we are now considering differ so widely. We can hardly hope for many years to come to improve the load-factors of works for general supply much above 20. The average of the London stations is still a long way off this figure, and I fear that the extensions of the use of energy for power and purposes other than lighting are likely to go on for some years to come at a slow rate. At a load-factor of 20 you must remember that all maintenance charges work out nearly five times as great as they would be if the output was continuous. It is useless to put before you ideal figures which we cannot hope to approach. I propose, instead, to adopt figures which we may hope to reach at no distant period, and have, therefore, prepared those given on Table II., and I give reasons for fixing on them as I deal with each sub-head in turn.

TABLE II.—Ideal Standard Works Cost.

	Cost per unit sold.	d.	d.
Works cost—			
1.	Fuel—2·5lb. Welsh coal at 20s.	0·27	
2.	Water	0·01	
3.	Petty stores	0·02	
4.	Wages	0·10	
5.	Superintendence	0·10	
	Total works cost	——	0·5
Maintenance—			
6.	Material on repairs	0·20	
7.	Wages on repairs	0·15	
8.	Superintendence	0·05	
9.		——	0·4
10.	Management		0·42
11.			
12.	Profit		1·68
			3·00

Working expenses, 44 per cent. of receipts.

FUEL AND WATER.—DIVS. 1 AND 2.—FUEL.

I agree with Prof. Kennedy in the remarks that he made on my paper read before the Institution of Civil Engineers* that the importance of the cost of the fuel used on electrical energy supply works is not to be measured merely by the money spent on the fuel itself, but that it is to a certain extent a measure of the quantity of plant that must be employed, and so affects the cost of upkeep of the plant, and to some extent every cost item, except, perhaps, management and profit items. At a very early stage in the history of electrical supply works it was found that in practice the amount and cost of the fuel used differed very widely from the amount estimated from the known efficiency of the plant. In 1883 modern engine-builders were making engines and boilers using less than 2½lb. of good coal per indicated horse-power, and the mechanical efficiency of these engines was certainly not less than 85 per cent. At that time dynamos could be made of 85 per cent. efficiency. We all thought that our distribution losses should not exceed 15 per cent., so that, putting these figures together, we were justified in hoping that our fuel bill would not exceed 5½lb. of coal per unit sold. We soon, however, found that in practice we could not approach such a degree of economy, so that the opinions of practical engineers in charge of supply works rapidly veered round to the opposite extreme, and among these gentlemen, even in 1888, when I estimated that the figure which was then prevalent of about 24lb. of good Welsh coal used per unit sold might in the future be reduced to 5½lb., I met with much incredulity. At so late a date as that of my paper before the Institution of Civil Engineers in 1891,† Mr. Raworth, in the course of discussion, stated that to his knowledge from 19lb. to 22lb. of coal was commonly being used, and that he considered the figures I then gave—namely, 7·9lb. for the Kensington and 6·5lb. for St. James's stations, for the best months of the year—were so satisfactory that they opened up a prospect of a new era for shareholders in those companies. I am glad to say that since that date improvement has been very regular; during the past year we have several times seen recorded during the winter months—in which, of course, the economy of fuel is at its best—a fuel consumption under 5lb. of Welsh coal per unit sold; so that my forecast, made six years ago, has already been more than justified.

* *Journal*, Inst.E.E., vol. xvii., p. 349.
† *Proceedings*, Inst.C.E., vol. cvi., p. 2.

* *Proceedings*, Inst.C.E., vol. cvi., p. 2.
† *Proceedings*, Inst.C.E., vol. cvi., p. 2.

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I have arrived at my new possible or ideal figure of 2½lb. of Welsh coal per unit sold in the following manner: I find that we can in London count on obtaining this coal having an average calorific value of 14,500 B.T.U. per pound. With proper arrangements for heating the feed water to nearly boiling point boilers can be obtained which will evaporate 12lb. of water at our working pressure of 150lb. I think that the losses due to irregular working and banking fires can be so minimised that 2½lb. may evaporate 25lb. of water into dry steam—not on tests only, but as shown on the monthly bills. Condensing steam-engines can and will be made for us using not more than 12lb. of steam at from three-quarters to full load, or 13lb. of steam at from half to three-quarters load per indicated horse-power per hour. To these engines dynamos can be coupled direct of such efficiency that the combination will not use more than 18½lb. to 20½lb. of steam per unit per hour, measured at the dynamo terminals at the corresponding loads, so that an average of 20lb. per unit generated may be counted on during the time that these engines are actually at work. This allows for 10 per cent. of the steam evaporated being condensed in the pipes, or used in feed pumps or other obscure sources of loss, and a further 10 per cent. for our distribution loss, in order to account for the 25lb. of water I require to be evaporated by the boilers. It appears to me that the most convenient method of discussing the problem of reaching these ideal figures is to consider in turn the fuel that we use and the boilers and other steam-producing apparatus, the engines for using the steam, the dynamos for generating the energy, and, finally, the means for distributing the energy to the users—in each case with a view of locating the losses that now take place, and considering the best means of minimising these losses as far as may be possible. In London the favourite fuel hitherto used in electric supply works has been Welsh coal of the best quality, as it has been found that the cost of the carriage of fuel forms such a large part of its total cost when delivered on to the works, that in most cases it pays best to use nothing but fuel of the highest calorific value. This value in the case of the best Welsh coal may be taken at 14,500 British thermal units; for, although values as high as 16,700 have been noted in the case of Nixon's and a few other Welsh coals, yet it is probable that these exceptional values are not attained on the average, even from coal from the very same seam. As our ideal figure of 2½lb. therefore contains 36,250 B.T.U., it will be convenient, for purposes of comparison, or for considering the use of other fuel, to point out that 2½lb. of Welsh coal is equal to 36¼ B.T.U. per watt-hour of the energy sold. Table V. gives the calorific values of various fuels, determined by Bryan Donkin and Co., Limited, arranged in the order of their efficiency when used in a Lancashire boiler fitted with Perret's furnace.

I have been enabled, through the kindness of Messrs. Bryan Donkin, and Co., to avail myself of these figures, which show at a glance the (comparative) value of Welsh coal as compared with other steam coals, of large Welsh as compared with small Welsh, of small anthracite, large and small coke, and coke dust; and, for the information of those who hope for great things from the use of town refuse for steam-raising purposes, I give at the foot of this table Messrs. Bryan Donkin's determination of its value. The Perret furnaces used for these determinations is well suited for making such a comparison, as it burns efficiently all classes of fuel, even the smaller and finely divided coals, coal dust, coke breeze, and coke dust, and in these cases minimises the loss of small combustible, which is liable to fall through the grate bars. The results shown on this table emphasise the fact that in practice we can utilise a large percentage of the T.U. in such fuels as anthracite, Welsh coal, and coke, the heating power of which lies chiefly in the solid carbon which they contain; and that the small and dust fuels of the same class are only less valuable because a part of them is liable to fall through the bars, and because, being so finely divided, they usually contain more earthy matter to form clinker and ash in the furnace than the larger coals or cokes, which can be more easily hand-picked, sorted, or washed free from such impurities.

The very large class of steam coals used in the Midlands and North is only represented in the table by the one test of the Yorkshire Ravensworth coal, but the majority of these coals, whether large engine coal, nuts, or engine slack, only contain from 50 to 70 per cent. of carbon in the solid form, so that although on account of the T.U. contained in the combined carbon and in the hydrogen, these fuels, when tested in the calorimeter, may give a calorific efficiency approaching that of the anthracite and Welsh coals, yet we find very rarely that any form of furnace now in use is able to utilise any considerable percentage of these hydrogen units, even when the best of the modern automatic stoking apparatus is used. So that when judging the comparative value of these fuels we should always remember that it is far more difficult to obtain a high boiler efficiency from these latter fuels than from those which contain the larger percentage of carbon in the form of coke. In order that you may conveniently calculate the T.U. contained in a pennyworth of coal of various qualities and prices, I have prepared Table V. (*a*), which shows this at a glance for all fuels from 10,000 up to 16,000 B.T.U. per pound, and for all prices from 5s. up to 22s. per ton.

FUEL AND WATER.—DIVS. 1 AND 2.—BOILERS, ECONOMISERS, ETC.

The boilers which have hitherto been chiefly used in electric supply works have been of the locomotive, marine or semi-marine, tubulous, or Babcock and Wilcox type, and the Lancashire type.

Locomotive Type.—Several large locomotive boilers were put in by Mr. W. H. Maw for driving the *Daily Telegraph* printing works, and the success of these was so great that I asked him to design for me boilers of the same type for the first London central station, which my firm put down for the London, Chatham, and Dover Railway at Victoria Station in 1883. These boilers had copper fire-boxes, and on test trials gave an evaporative efficiency of 8½lb. to 9lb. of water per pound of Welsh coal. This type is in most respects satisfactory, but on account of the level of the grate bars being so much below the level of the fire-doors, it is difficult to properly clinker the fires—so much so that when a batch of coal is used that contains much clinker it is very difficult to clean the fires in a reasonable time, so that the evaporative efficiency is thereby much reduced. From this cause the average efficiency of locomotive boilers does not much exceed 7lb. of water per pound of coal when taken from the monthly bills, and under the conditions usually met with in supply works. It is also not an easy matter to bank the fires of a locomotive boiler in an economical manner. The St. James's and Pall Mall Company have used large boilers of this type made by Davey, Paxman, and Co.; and the Metropolitan Company have used others made by Hornsbys—all, I believe, with good results. I, however, have been unable to obtain the correct evaporative duty. This type of boiler is rather more costly to maintain than the other types; the fire-door ring is liable to give trouble from leakage, and a great deal of space must be wasted in order to give access to the smoke-box end of the boilers for tube-sweeping purposes.

The Marine and Semi-Marine Type.—The marine type has been used in a few instances, notably in the Whitehall Court station of the Metropolitan Company, and is highly economical, but it is a rather costly boiler to construct. Equally good results may be obtained from the semi-marine type, which is a modification of it, made by Messrs. Davey-Paxman, and others, which they call the "Economic" boiler. In this boiler the flues are carried right through from front to back, and the products of combustion are deflected back through the tubes by a firebrick back. In Scotland this boiler is called a "dry-back" boiler. It has many merits. It is very simple, and easily repaired. The intensely-heated "dry-back" acts as a very good smoke preventer, so that Midland steam coals can be used without producing smoke, which is not the case with either the locomotive or Babcock's type. Prof. Kennedy has used a large number of these boilers for the Westminster Supply Company, and, he tells me, with uniformly good results from every point of view. The test of this boiler given in Table IV. shows it to be of the highest efficiency. I have not personally had much experience in its use until quite recently at the new central station in Shoreditch for the Great Eastern Railway. The sole fault in this boiler (and it is not a great one) is the rather awkward position of the smoke-box over the fire-door.

Babcock and Wilcox Boilers.—These boilers, as you well know, consist of a large group of inclined tubes, having the water inside the tubes, the highest end of the tubes being at the firing end of the boiler. The tubes are connected at both ends by special headers to steam-drums placed overhead. The firing is carried on on large grates, and the products of combustion are deflected by fire-tile bridges, so that they are obliged to follow a serpentine course through the tubes, the hot gases passing several times transversely to the tubes. My experience in the use of Babcock boilers has been altogether satisfactory, and I believe that the best evaporative efficiency yet obtained in supply works has been with these boilers. I make this statement all the more readily as in my 1891 paper* I said that this class of boiler, presenting as it does such considerable radiating surface of brickwork, would not give such economical results during the long hours of standing with banked fires as other boilers which are internally fired; but since that date the skill of the designers, and the great skill and attention of the users, has resulted in so minimising these losses, that I believe these boilers stand quite at the head of the list, not only as regards economical working on full-load tests, but also in the small use of fuel when standing banked. These are my own observations, but I understand that the experience of others has been equally satisfactory, at least wherever Welsh, anthracite, coke, or other smokeless fuels are used. I am told that when used with smoke-producing fuel there is a tendency for the lower rows of tubes to cool down the products of combustion, that these tubes become coated with soot, and the evaporative result is unsatisfactory. I believe, however, that the makers have now introduced special means to get over this difficulty. The chief refinements that those who use these boilers have been able to introduce, and which have led to reduction in the waste of fuel during long hours of light firing and banking, are principally in the alteration of ashpit, flue doors, and dampers, so as to regulate the air admission with great nicety, or to completely shut it off. We also find that the maintenance of the fire-tile bridges between the tubes which cause the gases to follow the undulating path above described is a matter of extreme importance, and last, but not least, this boiler should be kept perfectly clean. Up to a few years ago we were content with periodical cleanings and scalings; but now, by the use of suitable boiler fluids and frequent blowing off at the surface as well as at the lower cocks, we find that we can keep the interior of these boilers as free from scale, and in all respects as clean, as when they left the makers' hands. Test results with these boilers have shown that 9¾lb. of water can be evaporated with Welsh coal at 170lb. boiler pressure: if the calorific value of this coal is taken at 15,000, this is equal to 76½ per cent. efficiency; and, as my table of costs will show you, in practice we have reached to within a narrow percentage of this figure, even when all banking coal and other sources of waste are taken into consideration.

Lancashire Boilers.—We are told from time to time that the evaporative efficiency of this boiler ought to be the highest, and its maintenance cost the lowest, of any boiler. I believe the

* *Proceedings*, Inst.C.E., vol. cvi., p. 2.

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latter claim to be better founded than the former. The boiler is easy to clean, and the repairs should be few at low pressures and far between; but it must be remembered that we have no extended experience of the cost of maintenance of these boilers when used at the higher pressures of 140lb. to 170lb. per square inch, now so common in electric works—as, for instance, the maintenance of the usual fusible plug is not an easy matter, and it is therefore necessary to depend on some form of low-water alarm, which is always a troublesome piece of apparatus; again, although the accidental lowering of the water-level of a locomotive or a Babcock boiler, or an "Economic" boiler may have serious consequences, yet these are nothing to what occurs when the flues of a Lancashire boiler come down from this cause. As regards the evaporative efficiency of the Lancashire boiler, I think it has been somewhat overrated. Owing to the fact that the great majority of Lancashire boilers are in use in the Midland and Northern counties, where the fuel used is cheaper than that we use in London, and where little or nothing is said if smoke is produced, and where low cost of maintenance is of higher importance than high evaporative efficiency, mill engineers have been led to regard this as the one and only boiler; but that this type is not efficient when taken by itself, is amply proved by the fact that no first-class mill is ever fitted up without the addition of economisers—in fact, we may say that the Lancashire boiler without its economiser is only half a boiler. In most cases the gases would leave the Lancashire boiler at 700deg., leaving 300deg. to be taken out of the gases by the economiser; whereas in tests of the locomotive, marine, semi-marine, or Babcock boilers the gases leave the boiler itself at a temperature very slightly in excess of that of the steam, so that in this latter case an economiser would be a refinement, and not a necessity. I do not think this fact has been sufficiently brought home to us engineers when the merits of the Lancashire type of boiler have been so persistently put before us by outside engineers, so that many of us—myself included—have made the mistake of putting down Lancashire boilers for supply stations in country towns without economisers, thinking that if we made these boilers large for their work we should get the required economy, whereas with this type the only way to get high economy is to use a rather small boiler and a large economiser. At any rate, the electric works using Lancashire boilers have hitherto not shown at all well in comparison with other types. In towns where the fuel is obtained so near to the works that the cost of carriage is small compared with the actual cost of the fuel itself, it pays to put down boilers fitted with special stoking plant to deal with these inferior fuels. In most of these cases Lancashire boilers have been used, but, as I shall show hereafter, the results hitherto obtained from the use of such cheap fuel have not been very satisfactory; in fact, the very cheapness of the fuel itself has been a snare to the works engineers, causing them to neglect refinements in fuel economy to such an extent that in many cases the greater part of the saving which they ought to have shown from the low price of their fuel has been lost. In some cases the price of their fuel has been actually higher than in the best London works, where economical working has been studied.

It is now time to put before you in a tabular form the data which I have been able to prepare to show the working efficiency of the boiler plant used in 10 of the works which I propose to compare. In all cases the quantity and calorific value of the fuel used is given with sufficient accuracy; but I have not in all cases been able to ascertain the water used per unit with the same accuracy, although this would have been a very desirable check on my other figures. Table III. shows the actual boiler efficiency in these 10 works; I have designated them by letters, which enable you to identify them, in the following tables:

TABLE III.—Boiler Efficiency.

Works.	System.	Type of boiler.	Fuel. Class.	Fuel. Value in B.T.U.	Lbs. of fuel per unit sold. 1892	1893	Lbs. of water evaporated per lb. of fuel.	Efficiency of boiler.
								%
E	"Converted" alternating ...	Lancashire	Small...	11,300	21·0	23·0	4·12	38·0
N	"Direct"	,,	,, ...	12,000	17·7	17·1	5·0?	43·5
O	,, ...	,,	,, ..	12,000	16·6	17 0	6·0?	52·0
J	½ "Converted" alternating... ½ "Direct".....	,,	,, ...	12,000	16·0	14·8	5·2	45·2
I	½ "Converted" alternating... ½ "Direct" ...	Babcock and Wilcox	Welsh .	14,500	14·7	12·0	7·8	56·5
Q	"Direct"	Locomotive ...	⅔ Welsh ⅓ coke..	—	—	10·2	7·5	54·5
U	,, ...	Babcock & Wilcox..	Welsh .	14,500	8·9	8·0	7·85	57·0
V	,, ...	Economic.	,,	14,500	9·9	7·5	8·0	58·0
W	,, ...	Babcock & Wilcox..	,,	14,500	6·9	5·83	8·5	61·5

In all the tables they are arranged in the actual order of fuel economy, F showing the largest consumption of fuel per unit sold, and W the smallest. Table IV. gives the evaporative duty and efficiency of several types of boiler determined at special tests.

TABLE IV.—Recording Maximum Efficiency of Sundry Types of Boilers at Test Trials.

By whom carried on.	Boiler.	Fuel used. Description.	Fuel used. Cal. value.	Lbs. water evaporated. From and at 212°.	Lbs. water evaporated. From 170° to 150°.	Efficiency.
						%
J. F. Crosland...	Lancashire.....	Lofthouse unscreen'd nuts.	12,875	7·74	—	56·5
,, ...	With McPhail and Simpson's superheater.	,, ,,	12,723	10 05	9 3	76 3
J. Holliday, at Messrs. Bryan Donkin's works	Perret's grate with Lancashire.	Welsh small	16,734	9 96	9·2	65·9
,, ,,	,, ,,	Coke dust	8,400	6·02	5·5	69·3
Prof. Robinson, at St. Pancras	Babcock and Wilcox	Welsh.....	15,000	11·9	11·0	76·5
Prof. Kennedy, at Glasgow	Marine type ..	Coke	12,120	7·91	7·3	63·0
Prof. Kennedy, at Eccleston-place	Semi-marine type	Welsh.....	14,866	12 2	11·25	78 0
Prof. Kennedy, Nov. 26, 1888.	Thornycroft water-tube boiler	,, ...	14,900	13 4	12·4	86·8

TABLE V.—Calorific Values of Various Fuels, Determined by Messrs. B. Donkin and Co., Limited.

Fuel.	Description.	Where from.	Value in B. Ther. U.	Evaporation in boiler per lb. of fuel, lbs. of water from 80deg. F. at 50lb. pressure	Clinkers and ash, etc.	Efficiency of boiler.
						%
Coal	Large	Welsh, best	15,500	10·0	2·4	66·5
Coal	Small	Cheshire, Orrel Colliery Co. ..	14,500	8 7	2·4	64·0
Coal	Large	Welsh, Ocean ...	13 950	7·9	8·5	58·7
Anthracite .	Pea	Welsh, Llanelly .	13,840	7·7	5·2	57·0
Anthracite .	Nuts	Welsh, Llanelly .	13,560	7·7	6·6	58·5
Coal	Large	Welsh, Ffaldau .	13,560	7·7	9 5	58·5
Coal	Large	Yorkshire, Ravensworth	14,820	7·5	10·5	51·0
Coke	Large ...	London	—	6·85	—	—
Coal	Dust	Welsh.....	—	6·78	7·1	—
Coal	Small	Nottingham	11,630	6·5	12·9	58·0
Anthracite .	Dust	Welsh.....	13,700	6·35	6·2	47·0
Coke (ord.) .	Breeze ...	London	10,610	5·4	19·6	52·5
Coke	Breeze ...	Welsh (Ebbw) ...	12,000	5·4	5·5	46·0
Coke	Dust br'eze	Nottingham	11,200	3·7	20·0	33·8
Coke (pan) .	Breeze ...	London	8,840	3·32	28·6	—
Refuse	House (unsorted)	London	—	2·13	—	—

I would draw attention to the remarkably high results obtained by Prof. Kennedy, shown on Table IV., in his Glasgow trials, and beg that this result, which was obtained with marine-type boilers using small gasworks coke, may be compared with that shown by Bryan Donkin, in Table V., with a Lancashire boiler using similar coke. Referring to Table III., Works J are using Lancashire boilers fitted with automatic stokers of the Vicars type. In this case, which is under my own control, every means has been studied to increase the evaporative efficiency of the boilers; but this is a typical case of the difficulties attending the use of small coal, even if it be of fairly high caloritic value. In this case a considerable part of the loss is due to the small coal falling through the bars. The coal supplied is of variable caking quality: sometimes it cakes together sufficiently to reduce this loss; in other cases it hardly cakes at all, and from 15 to 20 per cent. of the combustible is lost. The point I have above referred to of the extreme difficulty of utilising the heat units in the hydrogen is here met with. If the air admission is not managed with the utmost nicety, the losses due to over-dilution of the products of combustion by air becomes so great that the evaporation is largely diminished, and this without any apparent neglect on the part of the stoker.

Before leaving the subject of boilers, I ought to say a few words on the use of forced draught. A good many of us have

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V. (a).—TABLE showing Number of British Thermal Units in One Pennyworth of Fuel of various Qualities and Prices.

Price of Fuel in Shillings per Ton of 2,240lb.

B. Th. Units per lb. of fuel.	5/-	6/-	7/-	8/-	9/-	10/-	11/-	12/-	13/-	14/-	15/-	16/-	17/-	18/-	19/-	20/-	21/-	22/-
10000	373300	311000	266666	233333	207407	186666	169600	155555	143589	133333	—	—	—	—	—	—	—	—
10200	380800	317200	272000	238000	211600	190400	173100	158600	146500	136000	126900	—	—	—	—	—	—	—
10400	388300	323400	277300	242700	215700	194100	176500	161700	149300	138600	129400	121300	—	—	—	—	—	—
10600	395800	329700	282700	247300	219850	197900	179900	164900	152200	141300	131900	123700	116500	—	—	—	—	—
10800	403300	335900	288000	252000	224000	201700	183300	167900	155100	144000	134400	126000	118600	112000	—	—	—	—
11000	410800	342100	293300	256700	228100	205400	186700	171100	157900	146600	136900	128300	120500	114100	108000	—	—	—
11200	418200	348300	298700	261300	232300	209100	190100	174200	160800	149300	139400	130700	123000	116200	110000	104500	—	—
11400	425700	354600	304000	266000	236400	212900	193500	177300	163700	142000	141900	133000	125200	118200	112000	106400	101300	—
11600	433200	360800	309300	270700	240600	216600	196800	180400	166600	154600	144400	135300	127300	120300	114000	108300	103100	98400
11800	440600	367000	314700	275300	244600	220300	200200	183500	169400	157300	146900	137700	129600	122800	116000	110200	104900	100100
12000	448100	373200	320000	280000	248800	224000	203600	186600	172300	160000	149400	140000	131800	124400	118000	112000	106700	101800
12200	455600	379400	325300	284700	252900	227800	207000	189700	175200	162600	151900	142300	133900	126500	120000	113900	108400	103500
12400	463000	385700	330700	289300	257100	231500	210400	192800	178100	165300	154300	144700	136200	128500	121700	115800	110200	105200
12600	470500	391900	336000	294000	261200	235200	213800	195900	180900	168000	156800	147000	138400	130600	123600	117600	112000	106900
12800	478000	398100	341300	298700	265400	239000	217200	199000	183800	170600	159300	149300	140500	132700	125700	119500	113800	108500
13000	485400	404300	346700	303300	269500	242700	220600	202100	186700	173300	161800	151700	142800	134700	127500	121400	115600	110300
13200	492900	410600	352000	308000	273700	246400	224000	205300	189500	176000	164300	154000	145000	136800	129500	123200	117300	112000
13400	500400	416800	357300	312700	277800	250200	227400	208400	192400	178600	166800	156300	147100	138900	131750	125100	119100	113700
13600	507800	423000	362700	317300	282000	253900	230800	211500	195300	181300	169300	158700	149400	141000	133500	127000	120900	115700
13800	515300	429200	368000	322000	286100	257600	234200	214600	198200	184000	171800	161000	151500	143100	135750	128800	122700	117100
14000	522800	435400	373300	326700	299300	261400	237600	217700	201000	186600	174300	163300	153700	145200	137500	130700	124400	118800
14200	—	441700	378700	331300	294400	265100	241000	220800	203900	189300	176800	165700	156000	147200	139500	132500	126200	120500
14400	—	—	384000	336000	298600	268800	244400	223900	206800	192000	179200	168000	158100	149300	141500	134400	128000	122200
14600	—	—	—	340700	302700	272500	247800	227000	209600	194600	181700	170300	160300	151400	143500	136300	129700	123900
14800	—	—	—	—	306900	276200	251200	230100	212500	197300	184200	172700	162500	153400	145500	138100	131500	125600
15000	—	—	—	—	—	280000	254500	233200	215400	200000	186700	175000	164700	155500	147200	140000	133300	127300
15200	—	—	—	—	—	—	257900	236300	218200	202600	189200	177300	166900	157600	149100	141900	135100	129000
15400	—	—	—	—	—	—	—	239400	221100	205300	191700	179700	169100	159600	151000	143700	136900	130700
15600	—	—	—	—	—	—	—	—	224000	208000	194200	182000	171300	161700	153000	145600	138600	132400
15800	—	—	—	—	—	—	—	—	—	210600	196700	184300	173500	163800	155000	147500	140400	134100
16000	—	—	—	—	—	—	—	—	—	—	199200	186700	175700	165800	157000	149300	142200	135800

formed the opinion that one of the best methods of meeting the short period of heavy load is by the use of forced draught applied to a closed ashpit, as has been done by Meldrun and others. It is evident that existing boiler plant might, in case of emergency, or for short periods, be forced to evaporate 50 per cent. more steam than at present; and this would be particularly convenient to meet the times of maximum load, so that in this way the waste of fuel due to lighting up extra boilers for these short periods might be reduced or altogether avoided. We should also be able to burn small or finely divided, and hence cheaper, fuel during the times of light load in an efficient manner. Another method of reducing the cost due to the necessity of lighting up additional boilers for the period of maximum load would be by using liquid fuel, to be used only on emergency or during these periods of maximum load. As is well known, Mr. Holden, on the Great Eastern Railway, has been very successful in the use of astatki, or crude petroleum, with his works boilers, and on some of the locomotives of the Great Eastern Railway. The principal objection to his system appears to be the noise of the blower, and the same applies to nearly all the systems of forced draught where an injector blower is used; but there seems little doubt that this noise may be minimised by properly arranging the air inlet—that is to say, by drawing the air from a point outside the building, placed so that the noise at the entrance cannot be a nuisance to the neighbours. As it is evident that it is very easy and convenient to safely store such liquid fuel in deep underground tanks, and, as is evident, in face of the troubles we have lately gone through from the coal strike, that it is necessary to have such a considerable storage, this question of the employment of liquid fuel deserves careful attention by all interested in supply works.

There is another point to which I wish to call attention. A long and interesting series of articles has recently appeared on water-tube boilers in the *Engineer*, in the course of which the writer more than once states that it is impossible to force any of the existing types of water-tube boilers, as any such forcing invariably results in the production of wet steam, and consequent loss of economy. It is difficult to know how the writer could have formed such an erroneous impression. My own experience is that the works where the best results have been obtained are those where the Babcock and Wilcox boilers have been forced the hardest. At Works W, the boilers, which are nominally supposed to evaporate 11,000lb. of water per hour, have frequently been forced to 16,000, or about 50 per cent. in excess of the duty guaranteed by the makers, and at such times of heavy forcing there has never been any trace of priming or wet steam.

On the whole, I think that there is a fair prospect of improving and supplementing our boiler plant and our methods of working it so that we may obtain in the future an average boiler efficiency of 70 per cent.—equivalent to an evaporation of 10lb. of water at a pressure of 150lb. when using Welsh coal, and an equivalent smaller evaporation from inferior and lower-priced coal.

Fuel and Water.—Divs. 1 and 2.—The Effect of the Efficiency of Steam-engines on Dynamos or Alternators.

Now that so many supply works have been running for several years, and that the works accounts have been annually published in the full detail demanded by the Board of Trade requirements, so that the actual cost of fuel, water, stores, labour, and salaries, and actual output of energy delivered, are recorded, and are known to everyone who interests himself in these matters, it might be thought an easy matter to draw some useful conclusions from these published figures, so as to throw light on the comparative efficiency of the various systems and types of plant used in these supply works, but I regret to be obliged to confess that the drawing up of such comparative tables is not an easy matter. I have examined the published accounts of 23 important and representative electric supply works in order to compare for this part of the paper the cost of the fuel. From these I have prepared Table VI., which relates solely to fuel and water used. I must mention that in preparing this and the other tables I at first relied on the published accounts for the information as to fuel, stores, labour, and salaries, but as I found that several serious mistakes existed in the published analysis of such accounts, I in every case have taken the precaution of sending the figures to the engineer of each works, in order that he might satisfy himself of their correctness, and in most cases the engineers of these works have very kindly supplemented this figure by the other data required to bring this cost of fuel to a common basis for purposes of comparison.

The best method of comparing the comparative efficiency of the generating plant would be by comparing the weight of water evaporated per unit generated; but, as I have already pointed out when discussing the boiler question, this water measurement has been very rarely carried out, so that I am obliged to fall back upon the only certain measurement—that is, the weight of fuel used. I have written to all the engineers of the works named in these tables, and have in some cases received full information, in others partial information, and in a few cases have been refused all supplementary information. In the case where the information has been partially, or where it has been entirely withheld, I have been obliged myself to fill in the blanks by calculating them from the published costs and known calorific values of the fuel used. I have done this after having made careful enquiry in each case; and whenever there has been a doubt as to quantity, price, or calorific value, I have endeavoured in each case rather to favour that particular works. At any rate, any errors that may exist in these calculated figures cannot be large enough to affect the result which I now bring before you. In addition to the accounts of the 23 works examined, I have also examined the accounts of 10 foreign works; but I find their information is too incomplete and too difficult to bring to a basis of comparison with our English works, and I do not complicate my table by adding them in. Of the 23 English works examined, 10—viz., those at Bournemouth, Chelmsford, City of London, Eastbourne, House-to-House (London), Metropolitan, Newcastle and District, Newcastle-on-Tyne, Leeds, and Exeter—distribute the bulk of their output on the converted alternating system. Two works—viz., those at Chelsea and Oxford—distribute on the converted continuous system. Eleven works—viz., Birmingham, Bradford, Brighton, Charing Cross and Strand, Hove, Kensington, Knightsbridge, Liverpool, Preston, St. James's and Pall Mall, and Westminster—distribute on the direct system.

In Table VI. I have grouped these 23 works into these three systems of distribution, and have arranged them in each group in order, always heading the list by the works that uses the largest quantity of fuel. It is curious to remark that this system of

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TABLE VI.—Comparison of Fuel Used.

Works.	Distinguishing letter	Cost of fuel per unit sold.	B. Th. U. in fuel used per watt-hour.	Efficiency of distribution.	B. Th. U. per watt-hour generated.	Description of plant.
Converted alternating system.				%		
Newcastle and District	A	0·8	310	70	218	Steam-turbine.
Leeds	B	1·23	300	66	200	Alternators, rope-driven.
Bournemouth ...	C	1·81	232	69	160	,, ,,
House-to-House	D	1·93	265	66	175	,, ,,
Newcastle-on-Tyne	E	0·64	262	66	173	,, ,,
Metropolitan ...	F	1·8	232	66	153	(1892) Mixed system.
Eastbourne.....	G	1·42	180	60·8	109	Alternators, rope-driven.
Exeter	H	1·35	135	66	89	,, ,,
Average of B, C, Mixed system.	D, E, & F		245	—	161	
City of London	I	1·24	172	82	141	Mixed system, driving.
Chelmsford	J	0·96	146	76	112	,, ,,
Average of I & J Converted continuous.		—	159	—	126	
Chelsea.....	K	1·11	142	62	88	Dynamos, driven direct
Oxford	L	0·70	88·5	62	55	,, rope-driven.
Average of K & L Direct system.		—	115	—	72	
Preston	M	1·65	315	80	255	Dynamos, driven direct by double-acting engines
Liverpool.....	N	0·95	186	75	143	Dynamos, driven direct by single-acting engines
Birmingham ...	O	0·88	183	75	140	,, ,,
Charing Cross and Strand...	P	1·13	147	90	132	,, ,,
Hove.....	Q	1·26	147	82	120	,, ,,
St. James and Pall Mall	R	0·95	126	90	114	,, ,,
Bradford	S	0·66	119	88·7	110	,, ,,
Brighton	T	0·904	117	80	94	,, ,,
Kensington.....	U	0·87	116	86·5	100	,, ,,
Westminster ...	V	0·78	104	88	92	,, ,,
Knightsbridge.	W	0·632	84	91·5	78	,, ,,
Average of N to W		—	133	—	112	
Ideal works.....	—	0·27	36·25	90	32·6	

grouping also divides them very fairly into the two great divisions of (1) rope or belt driven plant, (2) direct-driven plant. In the first group I have averaged the fuel consumption in T.U. per watt-hour, omitting from the average the first-named works, as the conditions of working are somewhat abnormal; and, similarly, in the last group I have averaged the fuel consumption for the whole, with the sole exception of the first-named works—*i.e.*, Preston—the conditions in this case being also abnormal. These averages show that the consumption of fuel per unit sold in the first group is about 94 per cent. greater than in the direct group: but as this difference is made up very considerably by the difference in efficiency of distribution, I have calculated the actual fuel consumption at the terminals of the dynamo by the efficiency of distribution of the two systems, which I regret to say is in several cases an assumed figure, as in several cases it appears to be actually unknown to the works engineers themselves. The table shows that, whereas the efficiency of distribution of the converted alternating systems is apparently somewhat under 66 per cent., with the direct systems (excluding the two-wire systems) it is about 86 per cent. The fuel used per unit generated in the converted alternating systems appears to be 43 per cent. higher than that used by the direct systems. In making these calculations I have carefully avoided considering those where a mixed system of distribution is used. The table also shows that the fuel average of the works where the alternators or dynamos are rope-driven is about 46 per cent. higher than where the dynamos are direct-driven by high-speed engines; and I think that the information that the table gives on this point is of the utmost importance, as it shows in a marked degree the economical advantages of high-speed direct-driven steam dynamos over slow-speed engines driving dynamos or alternators by ropes or belts.

Eight years ago I stood almost alone when I recommended that the 1,200-h.p. load of the Vienna central station should be divided amongst eight steam dynamos coupled direct to high-speed engines, as at that time most engineers still believed that high economy in the use of steam could only be obtained by putting down long-stroke slow-speed engines, such as are commonly used in cotton mills, and driving from these engines the dynamos by means of ropes or belts. This superstition was founded on the belief that steam could only be economically used in large engines of this type, which obtained their high piston speed by long strokes and few revolutions per minute; but it did not take long to show that the great variations of load in an electric supply works causes these huge engines to run for many hours at a very small fraction of their load, making them very uneconomical, so that the subdivision of their load between several smaller engines became necessary.

Mr. Willans, in his first and historic paper on steam-engine economy read before the Institution of Civil Engineers, was the first to strike a blow at the erroneous belief that economy could only be obtained from long-stroke, slowly-revolving engines, by showing that as the enemy to economy, particularly in the smaller engines, is cylinder condensation, the true way to reduce this is not by mere piston speed, as was the current belief, but by reducing the time during which the cylinder surfaces are exposed to the cooling action of the exhaust or of the condenser previous to each fresh steam admission—in other words, by using rapidly-revolving short-stroke engines instead of slowly-revolving long-stroke ones. Once this was understood, it followed that the high-speed engine making many revolutions, and therefore best suited for coupling direct to our dynamos, is also theoretically the most economical in use of steam. That this is also true in practice is shown by the long series of experiments carried out by Mr. Willans and the figures that I am now putting before you. The advantages of direct driving are obviously not confined to the Willans, or, indeed, to any single-acting, type of engine; in fact, we have now a considerable choice of high-speed engines, all of which can be coupled direct to dynamos, and which use their steam economically. There is one advantage common to all direct-driven steam dynamos—*i.e.*, their high efficiency in $\frac{\text{E.H.P.}}{\text{I.H.P.}}$ This efficiency, which has been gradually creeping up from 80 per cent., which was the efficiency we obtained from the Vienna steam dynamos in 1886, to the very high figure of 88 per cent., which has recently been obtained by a Willans-Siemens combination, has been much commented upon, and has in some quarters met with actual disbelief; but all who know how accurately the tests have been carried out at Thames Ditton, and who have themselves made independent check tests, know also that such an efficiency can be obtained without difficulty—in fact, that efficiencies in excess of 86 per cent. can now be guaranteed at full loads, and 80 per cent. at half loads.

The case is far different with rope or belt driven sets. In most cases it is difficult to obtain an efficiency of 78 per cent. at full load and 70 per cent. at half load when the engines are fitted with the ordinary unbalanced slide valve, or 80 per cent. at full load and 73 per cent. at half load when the engines have Corliss or balance valves. I must, however, note that Mr. Parker, in his paper—read before the Institution of Civil Engineers—on the Liverpool Overhead Railway, gives us the satisfactory results obtained from slow-running horizontal engines driving dynamos by ropes; but, although I do not challenge Mr. Parker's ultimate figures, yet I think that without doubt he has made a mistake in his calculated efficiency—that is to say, $\frac{\text{E.H.P.}}{\text{I.H.P.}}$. I think that it would be difficult for me—or, in fact, for anyone who has paid much attention to the losses due to the friction of steam-engines, and particularly of condensing engines, and to the losses occasioned by rope-driving—to accept Mr. Parker's figures. No one has made more careful experiments on the friction of such engines than Messrs. Sulzer, of Winterthur, and Messrs. Carels Frères, of Ghent, who make the same type of engines. I have been informed by the latter that an engine efficiency of 91 per cent. is only rarely obtained; generally, the efficiency is somewhat lower. Mr. Parker states that the electrical efficiency of his dynamos is 97·7 per cent., which is an extremely high figure. If we take the commercial dynamo efficiency at 96 per cent., which is an outside figure when we consider the side strains on the bearings caused by the rope-driving, and if we suppose that the loss due to the rope-driving is only 2 per cent., which I believe is less than has ever been noticed, it is just possible, with a 91 per cent. engine, a 2 per cent. rope loss, and a 96 per cent. dynamo, to get 86·6 per cent. efficiency.

Although I do not believe that such an efficiency, and correspondingly small consumption of steam per electrical horse-power at full and half loads can be obtained in practice by engines driving dynamos by ropes, yet it is so often attained by direct-driven sets that at least one maker can now guarantee figures very closely approaching the ideal figures I have given of 18½lb. of steam per unit at full load, and 21½lb. at half load. Yet in the cases of direct driving such high efficiency is easily accounted for. In the first place, the engines are fitted with piston-valves, which are the most perfect form of balanced valves; hence the internal friction of the Willans or Chandler engines, running as they do with all their parts thoroughly bathed in oil, must be probably lower than that of any other type of engine. Moreover, with direct driving there is no side strain whatever on the dynamo bearings, and even the downward pressure on these bearings can be partially eased by so placing the armature core in relation to the bore of the magnets that a certain amount of lift is given to the core at the time that the magnets are excited. Under such conditions it will be seen that the engine and dynamo mechanical friction can be reduced to a minimum—in fact, to a point very far below what is possible when any form of rope or belt driving is used. The figures that I now give show that the best results yet obtained have been with Willans engines driving direct-current dynamos, and I believe this is mainly due to the great reduction of friction which I have just mentioned, and which tells heavily in favour of this class of steam dynamo when it is only partially loaded. Hence we find that, whereas the combined efficiency of a Willans combination is as high as 80 per cent. at outputs as low as two-thirds full load, the combined efficiency of two-thirds load of a slide-valve engine driving a

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dynamo by belts or ropes rarely exceeds 70 per cent.; and, unfortunately, however much we may desire to keep the load-factor of the engine above 66 per cent., or two thirds, yet under existing circumstances it is a matter of difficulty to do so even in works where accumulators are used, and in works where there are no accumulators with all converted systems the average engine load-factor appears to be far below this.

As you no doubt expect me to express an opinion as to the cause of the wide differences in economies of fuel shown in these comparative tables, I must point out that, even if we exclude the difference in distribution efficiency by making the allowances that I have done, there still remain three sources of loss—one already dealt with under the heading of the boilers, and the second due to the engines, dynamos, or alternators, and the third to losses which have been called by Kennedy "obscure works losses." Now, I think the main cause of the difference in engine and dynamo losses lies in the fact that in the works under consideration the engines have been driven at widely differing load-factors; and, as whenever the engine load-factor is low the use of steam is correspondingly high, I think that this question of engine load-factor is of supreme importance. As I have shown above, a low engine load-factor tells more against belt or rope driving sets than against direct-driving ones; but in neither case has the subject received the attention that it deserves. Every facility should be given for the men in charge of the steam dynamos to ascertain for themselves at any time at what load-factor they are driving their plant, and if this were done more frequently I am sure that great improvements would result. One reason why at present the men in the supply stations know so little about this question is, that in most cases it is only looked into as a sort of holy mystery by the engineering staff, and at long intervals of time; whereas I feel strongly a book ought to be kept in every works, and the men in charge should always enter up the load-factor of each engine during the hours the stop valve is open; and in order that this may be done with a minimum of labour, I have devised and used in our Chelmsford works a system which I will here describe for the benefit of those who care to adopt it. The diagram before you has its base line marked off in percentages of the load of the engine; and the same line is, in addition, marked with the steam-chest pressure, corresponding to these different percentages of load. This steam-chest pressure can be noted by a carefully calibrated gauge fixed on the steam-chest of the engine, the calibration being carried out as each set of indicator diagrams and electric load readings are taken; the result being that the man in charge of the engine can see at a glance from these steam-gauges what ought to be the indicated and corresponding electrical horse-power that his engine is giving, and from the same diagram he is able to calculate the consumption of pounds of steam per hour. Opposite to each gauge pressure is entered the theoretical consumption of steam per horse-power per hour at the standard speed, ascertained from Mr. Willans's table. Thus, if the man in charge enters up these steam pressures of all the running engines every quarter of an hour, it is easy to prepare an accurate report on the engine load-factor of the day, and thus compare the calculated with the actual steam used during the run, so that men who habitually underwork their engines can be thus noted and reprimanded. Of course, I know from experience how much more difficult it is to work engines driving alternators at a high load-factor than is the case with continuous-current steam dynamos. This is partly caused by the comparative difficulty and complication involved in parallelising alternators, compared with the ease of throwing continous dynamos in and out of parallel on a storage system. In the latter case, the enginemen have only one order to observe—viz., to keep their engines as fully loaded as possible on a rising load, not to start an additional set until the sets previously running are considerably overloaded and on a falling load to shut down the sets at the earliest possible moment, even if it leaves the remaining sets somewhat overloaded for some time. Unless such orders are given and carried out to the letter, so that engine load-factors exceeding 70 per cent. on the average are obtained, it is useless to expect to reduce the consumption of steam below 50lb. per unit generated.

The other causes of waste of steam in electric supply works are those which Prof. Kennedy, in his lecture at the Royal Institution, speaks of as "losses about which we engineers feel very sore, and which sometimes try our temper and our patience greatly, and are not recognised as having any kind of respectable existence." These are those connected with leaks from boiler fittings and steam-pipes, with condensation losses in the steam-pipes, and due to the wasteful use of steam by all present known means of boiler feed. These losses have been ignored by engineers, and have never received the attention they deserve; but as they continue throughout the 24 hours, they amount to a very considerable percentage of the steam evaporated by the boilers, and, of course, tell most during the summer months, or, in fact, in any works where the load-factor is low. Engineers who have been most successful in dealing with these difficulties, and have minimised these losses to the greatest extent, are those who previous to entering electrical works have received a practical engine-room training, either as sea-going engineers or in engine-rooms of a similar class where fuel economy has been persistently studied. I believe the best remedy for the pipe condensation losses will lie in the direction of superheating the steam after it leaves the boilers. If we could superheat the steam so as not only to have no pipe condensation at all, but to deliver the steam to the engine cylinders at a temperature 8 or 10 per cent. above the corresponding temperature for saturated steam, I believe that we should at once save nearly 10 per cent. of the steam that we now have to evaporate in our boilers. It is very easy to talk of superheating steam. In the days of low-pressure steam at 15lb. pressure, such superheating was a reasonably easy matter; but the case is widely different when the high-pressure steam leaves the boiler at a temperature of 375deg., as is now the case. Any further superheating is very much in the nature of passing this steam through pipes at a temperature which nearly amounts to red heat, so that it is little wonder that not many engineers have cared about tackling such a difficult and risky problem; but it is quite certain that this problem will be tackled, and I have recently heard that it has been satisfactorily dealt with by Messrs. McPhail and Simpson, the superheater consisting of a large number of bent tubes made of thick lap-welded iron, each tube being only about 1in diameter. The bent portions of these tubes are so placed that they are exposed to the hot gases when they first pass through the flues of the boiler, such as the space at the end of a Lancashire or of an "Economic" boiler; in the case of the Babcock boiler it would be more difficult to find a place for them. It is evident that whoever attempts to deal with this problem of working out a satisfactory superheater will have a great many difficulties to deal with. The superheater must, as I have said, be placed so as to be exposed to the high temperature gases, and yet it must be accessible for ready replacing of the tubes and for repairs. Moreover, it must be easily put in and out of circuit, so that a failure of one of the tubes should not in any way cripple the steam supply of the works. These requirements are in a sense contradictory, but I have no doubt, now that so many minds are directed to this problem, it will be successfully dealt with.

Another point which is receiving the attention of all of us is the extended application of condensing plant. In situations where condensing water is available this problem presents no difficulty, but in a large number of cases condensing water is not available; and of late years—in fact, dating from the time of my 1891 paper—a number of proposals have been made to introduce what are called evaporative or surface condensers, which may be described as consisting of a very extended surface of tubes, through which the steam passes, the tubes being cooled externally, partly by an air-fan blast and partly by a limited supply of water trickling on to the outside of them. Of course, so long as the amount of water used is equal to the feed water used, there would be no advantage in using such a condenser, other than that the steam consumption may possibly be economised, especially at times of light load, so that the steam that is required to pass through the condenser would be proportionately reduced; but Mr. Ledward and several other gentlemen who have paid attention to this subject are confident that they will be able to eventually reduce the cooling water required to two-thirds of that of the ordinary feed water; and if this is the case, it will result in a very great advantage, not only in removing the nuisance—which some people insist is a real nuisance—of the steam issuing from the chimneys of the various supply works, but the difficulties with the boilers will be also greatly diminished. But it must be recollected that this use of condensing water entails the working out of several very difficult problems connected with the thorough filtering out of the oil contained in the exhaust steam before it is allowed to re-enter the boilers. The united opinion of nearly all boiler engineers and inspectors is to the effect that if the water contains the smallest percentage of carbonate of lime the entry of even minute quantities of oil into the boiler is likely to have disastrous effects. The oil forms with the carbonate of lime a covering to the flues and tubes of a highly non-conducting nature, which allows the iron or steel plates or tubes to be greatly overheated, and great damage is thus done; so that most boiler insurance companies absolutely forbid the returning of condensed water to the boiler unless it has previously passed through a purifying apparatus which absolutely frees it from the oil.

I have briefly mentioned how very considerably the wasteful nature of the steam-pumps that are at present available for boiler-feed pumps affects the total economy of the works. For some time past at Chelmsford I have attempted to deal with this difficulty by supplying my boilers with feed pumps electrically driven; and although these electrically-driven feed pumps are by no means as efficient as I hope to make them in the future, yet in their present state their use shows a marked economy over the Worthington or other direct-acting pumps that were previously employed. The electrically-driven pumps use the energy from the main switchboard, which is generated in an economical manner; whereas the direct-driven pumps are driven not so much by steam as by water condensed in their steam-pipes. I have over and over again called the attention of pumpmakers to the great want there is of a more economical steam-pump than is at present in the market; but there appears to be a difficulty in dealing with the question, I believe chiefly owing to the intermittent way in which these feed pumps are worked, so that between periods of working their supply steam-pipes get comparatively cooled. I have spoken of the difficulty I have met with in obtaining trustworthy figures as regards water consumption. This is mainly due to the fact that a thoroughly trustworthy water-meter is not an easy article to meet with. In order that such a water-meter may accurately record the water fed into the boiler, it ought to be placed between the feed-water heater and the boiler, so that any leakages that may occur at the pumps themselves, or in the line of pipes, or in the feed-water heater itself, may not affect the question of boiler evaporation. This necessarily means that such a water-meter must pass hot water. For several years past I have been using Schönheyder's meter in this position, with fairly satisfactory results, but in its present state it leaves much to be desired. The pins wear to such an extent that in our Chelmsford case we find it necessary to take the meter out and replace the pins and recalibrate it once every three or four months. The calibration of such a meter is not a difficult

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matter if the feed water in any part of its course passes through a rectangular tank, the cubic contents of which can be readily measured, and the water contained marked for each inch of height.

When speaking of the differences which exist between the calculated consumption of fuel and water by the plant when tested under full load, and that which is observed from the water and coal bills in the month's or year's working, I was at one time doubtful whether any single 24-hour test would include within it the observed losses; but during the past year, having made a large number of such 24-hour tests at our Chelmsford works, I have come to the conclusion that such 24-hour tests which follow a complete cycle of the working are a fairly trustworthy guide to the annual losses; and I cannot too highly recommend the practice of taking such tests, and of showing them graphically in the manner universally adopted by mechanical engineers, and shown by Prof. Kennedy in the discussion which followed on my paper in 1891. Diagram VII. shows the way in which we plot a 24-hour test at Chelmsford, and this may be applied to any other works. Many of you will ask how I have been able to obtain the electrical work at the terminals of the dynamo in the case of the Chelmsford works, where we use alternating dynamos. My answer is, that it is only during the last few months that I have been able to do this; and it is owing to the extreme kindness of Prof. Fleming, and his unwearied attention in perfecting the Mengarini wattmeter for our purpose, that we have been able to obtain a daily record of the electrical energy generated by our alternating plant, as well as that generated by our direct plant. Diagram VIII. shows an enlarged diagram obtained from this wattmeter, and we have divided it up into known portions of the load from cards taken on other nights. We are able to separate the load in the town shops from the load in private houses owing to the fact that it is the custom at Chelmsford on Wednesday night to close all the shops, so that our load on that night consists entirely of the public lighting, which is an ascertained and invariable quantity, on which is superposed the lighting in the private houses only. It will be interesting to many here to know that the circumstances under which we work at Chelmsford of supplying the light between certain hours has enabled us to greatly cut down the transformer loss, so that we have been able to show an efficiency of distribution reaching 76 per cent., which I believe is probably as high as has ever been reached with alternating plant; but if we were compelled to keep the supply up through the remainder of the 24 hours, I am afraid the state of affairs would be widely different. We are also aided by such a large part of our load being public lighting, which goes on throughout the entire hours of darkness in summer and in winter.

Fuel and Water.—Part III.

Effects of Distribution Efficiency.—I am obliged to introduce this question into this paper, as there can be no doubt that the high consumption of fuel shown by certain works is partly due to low distribution efficiency; but I do not propose to dwell on this highly important question, which merits a paper to itself, besides being of a highly controversial character. I find that in few cases have the engineers of supply works had the pluck to face this important problem, and to ascertain and state boldly what distribution efficiency they have noted. In several cases, however, this has been done, so that I am able to make the Table VI. reasonably complete. From it you will see that the efficiency of distribution of direct systems, including meter losses, varies between 85 and 91½ per cent., whereas that of converted systems varies between 60 and 82 per cent.; the higher figure being only found where the system of switching transformers in and out of circuit is practised. In the very small loss of from 10 to 12 per cent. observed in the direct systems are included all those due to the accumulators, to the C^2R losses in the mains, to leakage, and to meters failing to register; and I do not think it is likely in the future we shall be able to improve much, if at all, on this distribution efficiency—in fact, we are assured by our American friends that it would pay us better to somewhat reduce this efficiency by putting less copper in our mains; but we consider that our English practice is right, as in order to get thoroughly steady lighting and good regulation it is necessary to work at this high efficiency, and at the present price of copper it can be easily shown that it pays to do so.

Stores, Water, Labour, and Superintendence.

Under the head of "Stores used in the Generating Works" are usually included water (which in London and many other towns has to be paid for), oil, grease, waste, packing, gauge glasses, and other materials which are from day to day used in the working of a supply works. The decrease in the stores item in several of the companies has been very noticeable during the last few years of working. In the case of the Kensington Court works of the Kensington Company, the stores have in some months reached as low a figure as 0·025d. per unit sold, and there is no doubt that even a lower figure will be reached as the output and load-factor improve. In this question of use of stores the closed type of engine, such as those made by Messrs. Willans, Bumsted and Chandler, and Bellis, of Birmingham, compare most favourably with the open type of engines. During a visit paid to Vienna two years ago, I was told by Mr. Melhuish, the engineer-in-charge of the Imperial Continental Gas Association, that the consumption of oil by an open-type compound engine which they had recently erected in that station was 16 times as great as the consumption of oil by a Willans engine of equal power, and I think that in many cases differences almost as great as this will be observed between the two types of engines. When it is considered that in the close type the only glands there are to pack are those of the governor gland and at the two ends of the crankshaft, whereas in a compound or triple open-type engine there are certainly not less than eight important glands to pack, and not less than 20 oiling points requiring separate attention, it will be seen how great the difference is. In the case of rope-driving sets there are in most cases three dynamo bearings to be oiled instead of the one bearing in the case of the direct-driven set, and the side strain on the bearings necessitates nearly a fivefold use of oil. Table VII. gives the cost of stores in the same works as Table III., from which it will be seen that whereas some of the works using direct-driven plant have already come within a measurable distance of the figure of 0·03 for water and petty stores, those using belt, or rope driven sets, are a very long way from it.

Table VII.—Comparison of Stores, Wages, and Superintendence Costs.

Works.	Distinguishing letter.	Stores and water.	Labour and superintendence.	Description of plant.
Converted alternating system.				
Newcastle and District	A	0·27	0·83	Steam-turbine.
Leeds	B	0·21	1·37	Alternators, rope-driven.
Bournemouth	C	0·27	1·24	,, ,,
House-to-House	D	0·41	1·25	,, ,,
Newcastle-on-Tyne	E	0·163	0·72	,, ,,
Metropolitan	F	0·24	0·75	Mixed system.
Eastbourne	G	0·14	1·4	Alternators, rope-driven.
Exeter	H	—	—	,, ,,
Average	—	0·24	1·19	
Mixed system.				
City of London	I	0·23	0·91	Mixed system, driving.
Chelmsford	J	0·16	0·94	,, ,,
Converted continuous.				
Chelsea	K	0·34	0·77	Dynamos, driven direct.
Oxford	L	0·045	1·24	,, rope-driven.
Direct system.				
Preston	M	0·45	1·35	Dynamos, driven direct by double-acting engines
Liverpool	N	0·15	0·37	Dynamos, driven direct by single-acting engines
Birmingham	O	0·17	0·82	,, ,,
Charing Cross and Strand	P	0·185	0·61	,, ,,
Hove	Q	0·2	1·44	,, ,,
St. James and Pall Mall	R	0·11	0·75	(1892) ,, ,,
Bradford	S	0·094	0·81	,, ,,
Brighton	T	0·162	0·96	,, ,,
Kensington	U	0·15	0·61	,, ,,
Westminster	V	0·19	0·95	,, ,,
Knightsbridge	W	0·17	0·60	,, ,,
Average	—	0·15	0·72	
Ideal works	N to Q, S to W	0·03	0·2	

Items 4 and 5.—Wages and Superintendence in Works.—On Table VII. I also give these two items for all of the works, showing a somewhat slow progress towards my ideal figure of 0·2d. per unit. This table shows that the lowest figure yet reached is 0·38d. per unit; but, as this figure is very largely a question of output, it is certain that from the increase of output alone, and without the introduction of any refinements having for their object the reduction of the staff employed in the stations, the wages and superintendence charge may be easily brought down. It is evident, however, that this charge must be much higher in the case of belt or rope driven machinery than is the case with direct driving, and Table VII. shows this to a very marked extent. There is every reason to believe that with direct-driving closed-type engines 1,000 kilowatts will demand the services of only one attendant, whereas it is doubtful whether with rope or belt driven and open engines one man could attend properly to more than 600 kilowatts of plant. This, however, is only my opinion, as in neither case has the output of any existing works been sufficiently large to enable the attendants to have their time occupied in the most profitable manner; it is quite certain, however, that under present conditions the use of accumulator storage has a most important effect on reducing the cost of attendance. Whether this will be so in the future, when the all-night loads begin to be heavy, I am at present not able to say, but I hold a very strong opinion that a proper proportion of accumulator storage will even in large stations reduce the cost of attendance at least 30 per cent., and in smaller stations from 40 to 50 per cent.

Maintenance.—I have considered this part of the subject with considerable care. It is the one point on which existing opinions vary through very wide limits, and, as far as I can judge, opinions incline at present in what I believe to be an unsafe direction—that is to say, too much has been made of the extremely light cost of repairs of existing works during the few years that they have been

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running, and figures have been founded on this which I am afraid will turn out to be altogether illusory. In all other businesses the upkeep of boilers which require to be periodically fired up and cooled down, and which have to be heavily fired at times of maximum load, is put down at a figure varying from 5 to 10 per cent. on the original cost of the boilers. The upkeep of steam-engines when worked at a far easier rate than is usual in electric supply works is usually taken at from 3 to 5 per cent. on their first cost; whereas the published accounts show that nothing like these figures have hitherto been spent on, or put aside for, the maintenance of these parts of the plant. I do not think that any accurate estimates can be formed of the ultimate cost of maintaining electric generating and distributing plant, other than on a percentage basis such as I have introduced in both my previous papers. I have therefore prepared Table VIII. to show what has been my own experience in this matter. This table gives the actual sum spent on the maintenance of various parts of the plant of the works of the Kensington and Knightsbridge Company during the last four years out of the seven years that this company has been supplying electrical energy. I have given in the table the original cost of each part of the plant, and have worked out the annual percentage cost which the maintenance bears to the original cost. As some of the steam-engines and boilers of this company have been at work seven years, and the bulk of the plant has been at work five years, sufficient time has elapsed for the maintenance cost to have settled down to the figure at which it is likely permanently to remain. As might be expected, the upkeep of the boilers and the accumulators has been more costly than that of any other portion of the plant, but in neither case is the amount as high as I expected it would be. The noticeable feature is the very small sum spent on the upkeep of the engines, of the dynamos, and of the mains.

TABLE VIII.—Cost of Maintenance of Works for a Period of Four Years—1890, 1891, 1892, 1893.

Description of plant.	Original cost.	Spent on maintenance in four years.	Per cent. per annum on cost.
	£	£	%
Buildings	16,598	429	0·65
Boilers	8,124	1,704	5·23
Engines	9,900	704	1·77
Dynamos	8,660	264	0·76
Other plant	12,868	968	1·9
Accumulators	15,115	1,968	3·25
Mains and services	65,167	952	0·36
Meters	6,549	628	2·5
Total	£142,981	£7,616	1·35%

The cost of upkeep of the engines is confined to the substitution of small parts as they wear, by new parts supplied from store. It will be seen that the upkeep of the dynamos is almost nil; but I must direct particular attention to the small sum spent on the inspection and maintenance of the mains, as this vindicates my often-repeated assertions that a well designed and conducted bare copper system must cost less to inspect and maintain than any system of continuously-insulated cables. At any rate, the sum expended on mains as shown in this table is an outside sum, as it includes many alteration items which can hardly be considered as fair wear and tear, but rather in the nature of improvements, and thus chargeable to capital. The maintenance sum spent by this company has been sufficient to keep the plant in absolutely as good order as when it was first put down, and, as I have just said, in some cases has enabled improvements to be introduced which have been charged to revenue. This gives me hopes that future experience will not show any marked increase in these percentage rates, but rather the reverse; so that the ideal figure I have proposed of 0·4d. per unit, which on 5,000,000 units will yield the very respectable sum of £8,300 per annum, will be a sufficient sum to maintain the entire plant in perfect working order for ever.

I have now taken you through all the items of cost of an electrical supply works, and have endeavoured, as far as possible, to compare what has been done up to date with an ideal possible standard. Whether this standard be ever reached or no, I think it will serve the useful purpose of holding before you a goal which we may all strive to attain, and that without the necessity for bringing out any wonderful revolutions in our practice, or, in fact, doing anything but intelligently perfect and use our present appliances. I hope my efforts in preparing this paper will be appreciated by those to whom it is addressed. I personally have the warmest sympathy with and admiration for the work of the large number of young electrical engineers who are now scattered over the various supply works, and to whose efforts we are indebted for the very marked advance in economy that I have this evening brought before you. I sincerely hope and trust that the means I have adopted of circulating the paper before the meeting will have given time to these works engineers to appreciate some of my points, so that we may have the advantage of having the important questions that I have raised, ventilated and discussed by those who are most competent to do it—namely, the resident engineers of electrical supply works.

I cannot conclude this paper without expressing my thanks to the very large number of gentlemen who have assisted me in my labours. In order to get together the data necessary for the production of this paper, I have had to visit a number of stations, and write a large number of letters to the engineers of stations which I could not visit. As it may be the wish of many of these gentlemen to preserve their anonymity, I do not thank them by name. As regards stations with which I personally am closely connected, the importance of anonymity is not so great, and I have therefore the pleasure in stating that much of the splendid results that have been obtained from some of my own stations—the figures of which no doubt some of you have recognised in the tables before you this evening—are due to the continued hard and intelligent work of Mr. Miller, the resident engineer at Kensington; Mr. Barley, the resident engineer at Knightsbridge; and Mr. Pott, the resident engineer at Chelmsford.

[We are unable to give with this report the illustrations accompanying the paper. The text is fairly understandable without them, but we hope to be able to give the illustrations with the report of the discussion.—ED. *E. E.*]

At last night's meeting of the Institution the following candidates were balloted for:

Associates.—John Henry Bale, Lynton and Lynmouth Electric Light Company, Lynmouth, North Devon; Arthur Bentley, Electric Construction Company, Limited, Ferdinand-street, Chalk Farm; William Clay, 13, Claude-road, Roath, Cardiff; Christopher Charles Hart, jun., 404, Uxbridge-road, W.; Peter Charles Middleton, 115, Union-street, Aberdeen; Benjamin Young, 8, Coleshill-street, Birmingham.

Students.—Archie S. Cubitt, 85, Tyrwhitt-road, St. Johns, S.E.; Albert Alexander Horn, Hazledene, New Barnet, Herts.; Owen David Lucas, 10, Westbourne-terrace, Hyde Park, W.; Percival Thomas Moor, 17, West Hillary-street, Leeds.

LIGHTING POWER OF ALTERNATING ARC LAMPS.

In a work recently published concerning the Cologne and Amsterdam electricity works, some interesting information is given of the lighting power of alternating-current arc lamps in the latter town. They are 10-ampere lamps, and the results are as follow:

Volts.	Amperes.	Watts.	Intensity of light in normal candles. Horizontal.	Maximum.	Spherical.
28·5	11	313	150	550	275
32·5	10·5	341	93	423	205

It will be seen from these figures that a greater pressure than 28 volts is not advantageous. Further experiments with these lamps were made in the direction of ascertaining the influence of the current strength upon the lighting power of the lamps. The results were as follow:

Current in Amperes.	Pressure in volts.	Intensity in normal candles. Horizontal.	Maximum.	Spherical.
50	25	1,630	4,840	2,625
30	28	1,800	3,880	2,200
20	27·5	940	3,760	1,500
16	28	925	2,160	1,200
15	27·5	670	1,570	870
10	28	150	550	275
8	30	92	530	250

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

THE NORTHERN SOCIETY OF ELECTRICAL ENGINEERS—A CORRECTION.

SIR,—In the report of my remarks during the discussion at the above society, published in to-day's issue of your paper, you give me credit for more than I deserve. The last 30 lines of my remarks (as given) should be put down to Mr. Nisbett's account, as he is responsible for them.—Yours, etc., JOHN H. RIDER.

Bolton, April 20, 1894.

SIR,—In my paper read before the Northern Society of Electrical Engineers on April 9, I am reported to have said that a meter on the principle of Ferranti's mercury bath was designed and exhibited by Lord Kelvin. As a matter of fact this is not the case, and I corrected myself while reading the paper. A meter on this principle was first designed in 1883 by Mr. Ferranti, and another of his patents covers the principle of partially floating the fan immersed in the mercury bath.

Thanking you for inserting this correction—Yours, etc.,

London, S.W., April 23, 1894. R. P. WILSON.

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THE
ELECTRICAL ENGINEER.

Published every Friday.
rice Threepence; Post Free, Threepence Halfpenny.
Editorial and Publishing Offices:
139-140, SALISBURY COURT, FLEET STREET,
LONDON, E.C.

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TO CORRESPONDENTS.

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WHEN DOCTORS DIFFER, WHO SHALL DECIDE?

In our opinion, as we have often pointed out, one of the greatest developments of electricity in the future will be in sanitary work. Holding this opinion, we awaited with considerable interest the result of the Worthing experiments, and gave the report of Dr. Kelly in full. Since then we have received the report of Dr. Alain Piton made to the Municipal Council of Brest. These two experts differ considerably in their conclusions, although made upon the same process. In asking how such differences can arise, we are led to the conclusion that in one case inferences must have been deduced from too few data. As yet but two systematic attempts have been made to employ electricity in sanitary work on a large scale—those of Mr. Webster and M. Hermite. Of late, Mr. Webster's process seems to have dropped somewhat out of competition, while M. Hermite's has come on. The main argument for the necessity of using some artificial method of disinfection is that, under existing conditions of civilised life, Nature has neither the time nor the opportunity of doing this work. According to the teaching of the time, Nature's great disinfectant is oxygen, and given enough oxygen in an active state, danger of infection may be averted. Now both Webster's and Hermite's processes provide for enormous quantities of oxygen either directly or indirectly, and profess to do in a short time and under given conditions the work for which Nature requires more time and different conditions. Electricians know little about sanitary engineering; they know little of sewage schemes, sewage farms, or effluents, but of these they must learn. The land suitable for sewage farms cannot always be obtained near large towns, the sea is not always available, and other means than pouring the sewage into rivers must be adopted. As population increases, the question of sewage treatment becomes more and more important. An electric current enables us to generate at will the required disinfectants, whether oxygen or chlorine. M. Hermite's system, as we have said, has been reported upon in two different quarters, with two different results. The concluding paragraph of Dr. Kelly's report (*Electrical Engineer*, April 6, page 413) reads as follows: "Since there is no instantaneous decomposition of fæcal matter, and *no sterilisation of sewage, etc.*" The italics are ours. Turning now to Dr. A. Piton, page 18, we read, "Ten cubic centimetres of electrolysed solution at 1 per 1,000 sterilises in half an hour one cubic centimetre of simple culture in broth of cholera bacillus, typhoid bacillus, or bacillus subtilis 'spore.'" Other experiments with different strengths of solution gave similar results, and he goes on to say, "One may then conclude that the antiseptic action of electrolysed sea-water is evident on the bacilli after half an hour of contact. Further trials will determine if the dose of antiseptic and the duration of contact may be reduced." Dr. Piton is not content with examining the action upon culture, but pointing out that unless the action is similar upon fæcal matter the antiseptic is useless. He carried out a number of experiments upon fæcal matter, and says, page 26, "It requires more than 80 cubic centimetres of

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electrolysed solution of 0·25 gramme strength to sterilise one gramme fæcal matter." He also gives the results with other strengths of solution, considering both time and quantity necessary for sterilisation. It is unnecessary to quote more as to sterilisation: enough has been said to show how diametrically these two reports are opposed. We will only quote one more sentence from Dr. Piton. He says, page 28, "Urinals, house refuse, and bilge water in ships are quickly and effectively disinfected." This is a definite statement, and again is opposed to that of Dr. Kelly. So far as we can judge, the conclusions arrived at by Dr. Piton are from a far longer and more systematic series of experiments than those of Dr. Kelly, and it may be that less care was taken in the latter case to test the strength of solution, or to find the time required by the solution for complete action. Too great stress, indeed, seems to have been laid upon instantaneous action—an action that will never be obtained in practice, and one that is not at all necessary. A certain time can always be given for the action of the disinfectant or antiseptic, but it is important to know both time and quantity in order to satisfactorily design the required works. We hope these divergent expressions of opinion will be thrashed out in the paper which we see is promised from M. Hermite to the Society of Arts. It will be a pity if the inventor of the system which has been reported on lets the session pass without bringing the matter forward; hence we trust to see a definite date given for this promised paper.

PROF. KENNEDY AT THE MECHANICAL ENGINEERS.

From a communication elsewhere in our columns it will be seen that Prof. Kennedy's remarks upon electrical traction are not to go without adverse comment. While, however, there are in this excellent address remarks with which we differ, we are not quite sure that Mr. Lea fully grasps the tenor of those on traction. There is, of course, the usual divergence about actual figures, but, on the whole, the difference of opinion may be summed up in a few words. It seems to us that the text, or at any rate one text, of the president of the Mechanical Engineers is that, other things being the same, the interposition of another piece of apparatus in a chain of mechanism decreases the efficiency of the combination, and this no matter how efficient the apparatus may be in itself. Mr. Lea will no doubt agree to this, but he contends that though there may be a decreased efficiency in one direction, you are able to get a new combination and increase the efficiency in another direction. He contends, in fact, that the stationary engine is the more efficient, and this increase of efficiency more than counterbalances the decrease of efficiency between the points of generation and use. We are quite content to let time operate in bringing these divers opinions nearer together. Prof. Kennedy would no doubt argue that he perfectly understands the expediency of utilising electricity in certain cases, and that its use would show to great advantage over competitors, but that generally his conclusions are legitimately deduced. We do not think the question of electric traction is to be decided generally by any comparison with steam; hence our greater or less indifference to controversy on this particular part of the subject. Steam traction on tramways will not be tolerated in thickly-populated towns to any great extent. It exists in a few cases, but in each of these it is tolerably clear to the initiated why it so exists. The great question is, horses or electricity; and in the long run horses must go, even if it be only to please the goody-goody folks who love horses and hate cruelty, for in this case civilised cruelty is worse than that of savagedom. However, the ruling point is cost of horses *v.* cost of electricity, and if the latter can be shown by its supporters to approach the former, depend upon it, electric traction will gain in favour and be installed as quickly as financial considerations permit. Steam traction (at any rate as at present known) *v.* electric traction for general work on tramways is not within the bounds of practical politics.

A SYSTEM OF NOMENCLATURE FOR DECIMAL MULTIPLES AND SUB-MULTIPLES.

BY R. B. HAYWARD, M.A., F.R.S.

The magnitudes with which the modern physicist and engineer have to deal extend over so wide a range—from millions or billions of some unit to millionths or billionths of the same—that some system of nomenclature for these multiples and sub-multiples—universal, simple, self-interpreting, and with the minimum of arbitrariness—could hardly fail to be a boon for individual use, and still more if generally adopted.

Dr. Houston and Mr. Kennelly have proposed in the *Electrical Engineer* of the 20th inst. a system which satisfies to a certain extent some of the above conditions, but fails in respect of others. It deals with thousandths and millionths, but not with hundredths, ten-thousandths, etc., and the terms are not self-interpreting—*e.g.*, *mega-* and *micro* do not in themselves express 10^6 and 10^{-6} times the unit respectively, but only by a convention, the exact terms of which (I know by experience) those who only need to use them occasionally are liable to forget.

I propose, therefore, to explain a system which I have for some time advocated but not hitherto published in a generally accessible shape, and for which I think I may claim that all the conditions I have laid down above are satisfied. The system is this:

Take any unit, known by its fundamental name (metre, dyne, ohm, etc.), and express by the *affix -n*, *-en*, or *-on* ten times that unit, and by the *affix -t* or *-et* one-tenth of the unit. *Prefix* to these the syllables (of Greek origin) *mono-*, *di-*, *tri*, *tetra-*, etc., to express the *index of the power* of 10 by which the unit is multiplied, the syllable used with the *-n* affix denoting a positive, and that with the *-t* affix a negative index. Thus we obtain the following universal system (exemplified in the case of the metre):

Metres (or other units).	Proposed name.	Name in the metrical system.
10^5 or 100,000	pentametron	?*
10^4 or 10,000	tetrametron	myriametre.
10^3 or 1,000	trimetron	kilometre.
10^2 or 100	dimetron	hectometre.
10^1 or 10	(monometron, or simply) metron	dekametre.
10^0 or 1	Metre	Metre.
10^{-1} or ·1	(monometret, or simply) metret	decimetre.
10^{-2} or ·01	dimetret	centimetre.
10^{-3} or ·001	trimetret	millimetre.
10^{-4} or ·0001	tetrametret	decimillimetre.
10^{-5} or ·00001	pentametret	centimillimetre
10^{-6} or ·000001	hexametret	?*

* The Greeks and Romans have failed to provide us with single words for such high numbers as millions and upwards. At least, our grammars and dictionaries generally stop short at 10,000 or 100,000.

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The simplicity of the proposed names over those of the metrical system, within, as well as beyond, the limits kilo- and milli-, hardly needs remark. The system has so great an advantage in fixing the attention on the *order* or *place* of a digit (which in using logarithms is the *characteristic*), that I believe it would greatly facilitate the teaching of decimal arithmetic if, instead of the ordinary words ten, hundred, tenth, hundredth, etc., the pupil were taught to use the words *dek*, *didek*, *tridek*, etc., *deket*, *dideket*, *trideket*, etc.; so as, for example, to read the number 5007·0805 as five trideks and seven and eight didekets five tetradekets. Then the product of one tridek and one dideket would readily be seen to be one dek ($3-2=1$), or of eight didekets and five tetradekets = 40 hexadekets ($-2-4=-6$), or the quotient of eight didekets by two trideks to be four pentadekets ($-2-3=-5$).

It will be observed that this system, besides being very simple, is universal in its applicability to any units, that the words interpret themselves without any doubt or hesitation as to their meaning, and that the only arbitrary element is the affix to denote whether a multiple or sub-multiple is to be understood. A few examples will, I believe, conclusively show its advantages.

One foot-pound = $1{\cdot}356 \times 10^7$ ergs, and is therefore in our language 1·356 heptergons.

One horse-power = $7{\cdot}46 \times 10^9$ ergs/sec, and is therefore in our language 7·46 ennergons/sec.

One megadyne, or 10^6 dynes, is one hexadynen.

One micrometre, or 10^{-6} metre, is one hexametret.

Mean distance of the moon = $3{\cdot}844 \times 10^{10}$ centim., read as 3·844 octometrons.

Mean distance of the sun = $1{\cdot}847 \times 10^{13}$ centim., read as 1·847 hendekametrons.

Wave length of D line = $5{\cdot}892 \times 10^{-5}$ centim., read as 5·892 heptametrets.

Number of vibrations per second for D line = $5{\cdot}097 \times 10^{14}$, read as 5·097 × tetrakaidekadekets.*

Energy of heat (J) = 4·2 heptergons per gramme-degree (water).

Dr. Houston's *begohm*, *tregohm*, *quegohm* become in our system *ennohmen*, *dodekohmen*, *pentekaidekohmen* respectively, and his *bicrofarad* becomes *ennafaradet*. If some of these words were felt to be inconveniently long, they might perhaps be shortened by a second *affix* at a certain stage: thus, if a *dekohmen* were called an *ohmenem*, the *dodekohmen* would become a *trinohmenen* and the *pentekaidekohmen* a *hexohmenem*.

PROF. KENNEDY AND ELECTRIC TRACTION.

BY FRANK B. LEA.

Prof. Kennedy has—quite deservedly—obtained a prominent position in the electrical world as an engineer of great skill, experience, and ability, whilst his fairness and impartiality when acting as a consultant stand out rather conspicuously in regard to the average of such qualities. But it is evident that the professor is a mechanical engineer first and an electrical engineer afterwards—if we are to separate the two. The fact of his being president of the Institution of Mechanical Engineers helps partly to explain this, and the address which he gave from the chair before the members of the institution last week may be considered an illustration of it also.

Of course, before such an audience, the professor may have thought it only fair to present in as favourable a light as possible the methods of traction which rely on what may be called purely mechanical principles, and yet the interweaving of electrical with mechanical should have become so intimate that contrasts or comparisons between the main group and the new branch or section would be as impossible as useless. In the case of an electric railway, said the professor, we have truly a saving of weight in the locomotive, but against this advantage, and the fact that a stationary steam-engine can be operated more economically than a steam locomotive, must be set the inefficiency of the whole arrangement. On this point some figures are given which for the professor's sake I will assume were obtained some considerable time ago. One can otherwise hardly credit the statement which he made as to the total efficiency on electrical railways or tramways being no more than 35 per cent., as compared with 80 per cent. on the steam lines. Has Prof. Kennedy analysed the working returns on the Liverpool Overhead Railway, where the ratio between electrical horse-power on the line and indicated horse-power at the station is as much as 88 per cent.? Has he forgotten the fact that on this very line the locomotive has been abolished altogether, the motor mechanism forming part of the passenger rolling-stock in such manner as to have actually no useless weight whatever? Has he, moreover, lost sight of the working results on lines even less favourably situated? Take, for instance, one of the numerous rack railways now at work in the mountainous districts of Switzerland. The Mont Saleve is at present the most important—if not the only one—of these operated by electricity, yet the mean working efficiency, with a most unfavourable arrangement and design of motors and gearing, is not less than 52 per cent. Of the losses, fully 16 per cent. must be set down to the imperfect gearing, so that by improvements in this alone the efficiency on the line would reach nearly 70 per cent.

One is not required in an electrical paper to discuss the economy of steam locomotives, and therefore I say nothing about the 80 per cent. efficiency which Prof. Kennedy—perhaps correctly—claimed for such, except to lay emphasis upon the considerable difference in fuel efficiencies between stationary and locomotive steam-engines. For many reasons he cares not at all for overhead conductors—who would, for that matter, if they had anything better?—and ignores them for the potential perfection of some underground system which has yet to be invented. I doubt very much whether even the late lamented prize of £50,000—or dollars, was it? it makes no difference, however—has succeeded in worrying enough grey brain matter to effect in any way a satisfactory solution of this problem, and to wait until we get one is to lose present advantages on a very large scale. Prof. Kennedy has, it is said, reported at some length and very favourably upon a compressed gas system of operating tramways—a system which is to work the traffic of ordinary lines at a total cost of 1d. per car mile. If this system is the one I have in mind, I feel pretty certain that if it only cost ½d. a mile, or if the tramway company were even paid for the privilege of letting the engines run, they would find it a bad speculation. Ordinary travel is provocative enough of the "railway spine," but to be jerked forward with a regular jerk periodicity of about three seconds would soon empty the cars and ruin the traffic. Moreover, gas and oil engines are all alike in one respect, and that is, their unpleasant qualities as neighbours. They have been said to "bark like a dog and smell like a cat," and the similes are by no means inappropriate.

With the cable system of traction one has no fault to find: it has a distinct field where even electric working may not compete successfully. But for Prof. Kennedy to say that electric traction is being hard pressed by its two rivals, cable and compressed gas, is equivalent to an assertion that the latest infant Hercules finds it a tough fight to turn a couple of harmless snakes out of his cradle. Electric traction must be allowed to exist before it can have any rivals; and for those in prominent positions (who are justly regarded as authorities on such points) to depreciate its possibilities when fairly treated, cannot be said to favour the progress of electricity in this or any other direction.

THE DUNDEE CENTRAL ELECTRIC LIGHT STATION.

There is a pretty common notion in existence among the inhabitants of England that the adjective of "bonnie" applies to the town of Dundee, whereas it is really a reference to the personal beauty of Graham of Claverhouse, Viscount Dundee. Dundee, the city of jute works, is not remarkable for its picturesqueness, and it looks infinitely better from the opposite shores of the Tay than when one

* The syllable "kai" might, perhaps, be omitted at the expense of linguistic accuracy, but remembering Lord Kelvin's *tetrakaidekahedra*, recently introduced to the public (*Nature*, March 8 and 15), I have not ventured to deviate from his examples.

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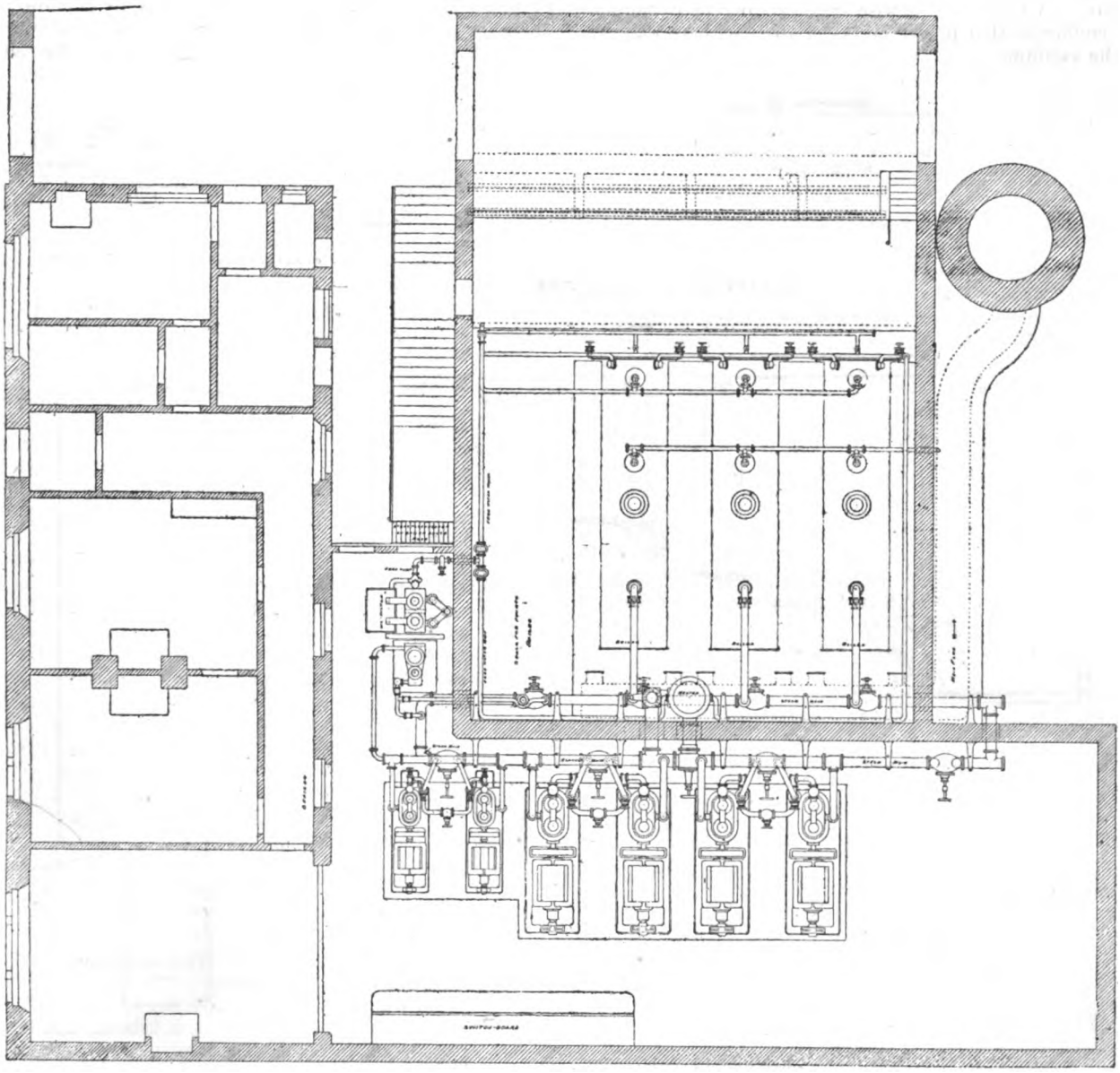
is actually in it. It is split up into business and residential sections, like most other towns; but many of its manufacturers choose to take up their abode at Broughty Ferry, a little nearer to the mouth of the river. It was, of course, to be expected that the inhabitants of a town of the importance of Dundee, which takes the third place in Scotland, would require the electric light; and their demands were met on March 15, 1893, when a public supply of electricity was commenced from a central station which faces the Dudhope-crescent-road.

The supply has been undertaken by the Dundee Gas Commissioners, and the available ground space at the generating station is sufficient to allow of extensions being made for a total of 20,000 16-c.p. lamps, or about three times the present capacity. The station is centrally situated between the business and residential parts of the city, and the method introduced is the three-wire system, the nominal pressure between the outside conductors being 200 volts.



Dundee Electric Light Station. FIG. 1.—General Plan of Station and Offices.

As will be seen from the accompanying illustrations, the buildings comprise a one-storey block, consisting of boiler and engine house, instrument, testing, and engineers' rooms, clerk's office, porter's lodge, storerooms, etc., and a basement accommodating a battery of accumulators. The general arrangement of the station is shown in plan in Fig. 1.

The steam-generating plant comprises three boilers of the Lancashire type, constructed for a working pressure of 140lb. There is, however, space for the accommodation of a fourth boiler. Each boiler is 24ft. long and 7ft. in diameter, and has two flues 2ft. 6in. in diameter. Provision has been made for equipping the boilers at any time with mechanical stokers. With regard to the feed water, special precautions have been adopted so as to prevent a failure in the supply. For this purpose each boiler is connected to two mains, one being fed by an injector and the other by a pump driven by an air-pump engine. Besides this, the two mains are again cross connected and fitted with valves in such a manner that either pump or injector can supply either or all the boilers through either of the mains. There is also provided a feed-water heater, heated by the exhaust from the steam-engines, and, if desired, the feed water from either of these mains can be passed through it. The arrangements adopted for the fourth boiler allow of its being connected to the steam and feed mains.

It will be seen from Fig. 1 that the steam-mains have been constructed in the form of a closed ring, divided into sections by means of stop-valves. A branch pipe is led to an engine from each side of a valve. This arrangement is amplified by the connection of the two branches—one on each side of a stop-valve—with one another again by a steam-pipe. This by-pass is joined into the branch pipes between the engine stop-valve, and another valve on the branch pipe. In the case of repairs being necessary on the main, this arrangement permits of the cutting out of a section by closing the valves. At the same time the engines connected to this section can still be supplied with steam from the pipe leading to the adjoining engine whether the engine is running or at rest. The steam-mains are made of wrought iron, the internal diameter being 8in. and the thickness ¼in. The flanges are also of wrought iron, screwed and brazed on, whilst the bends and T-pieces are of cast iron. The method adopted to avoid an unnecessary number of joints has been to cast the

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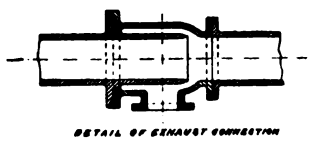
flanges, where the branches to the engine join on to the steam-main, in one with the valve bodies. The main is drained by three steam-traps. The main, being in the form of a closed ring, has not necessitated the use of expansion joints, more particularly as the branch pipes leading to the engines are of copper, and are sufficiently long to allow for expansion.

Similarly to the steam-main, the exhaust is also made of wrought iron, and it ranges from 5in. to 12in. in diameter, according to the amount of steam exhausting into it. Where the exhaust joins the main, it is constructed somewhat in the form of an injector. Thus the exhaust, instead of causing a back pressure, which would occur if carried in at right angles to the main, has a tendency to produce a vacuum behind it, and so assists in reducing the back pressure. Valves are likewise arranged on the exhaust of each engine, so that it may be taken apart without destroying the vacuum.

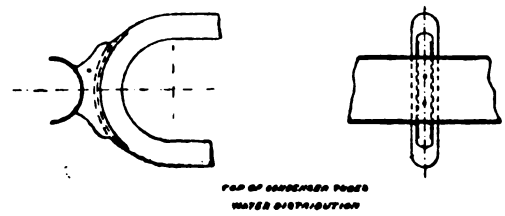
boiler-house, upon which six flat tanks are placed, of which four only are at present used.

There are four exhaust pipes above the tanks, and these communicate with the exhaust main. From the horizontal pipes there rise vertically 192 ∩ tubes. One leg of each ∩ connects with the horizontal pipes, while the second leg is joined to a smaller pipe, which runs parallel to the larger pipes. These smaller pipes and the air-pump are connected. The steam is thus obliged to ascend one leg of the ∩ and come down the other. The air-pumps draw off the condensed steam from the two horizontal pipes situated above each tank. The arrangement is illustrated in Fig. 3.

A gutter, supported on cast-iron feet, runs above each of the rows of ∩ tubes, the feet resting on the top of the ∩ tubes. The flat tanks already referred to contain the water for condensing purposes. A belt from the air-pump engine drives a centrifugal pump, which draws the water

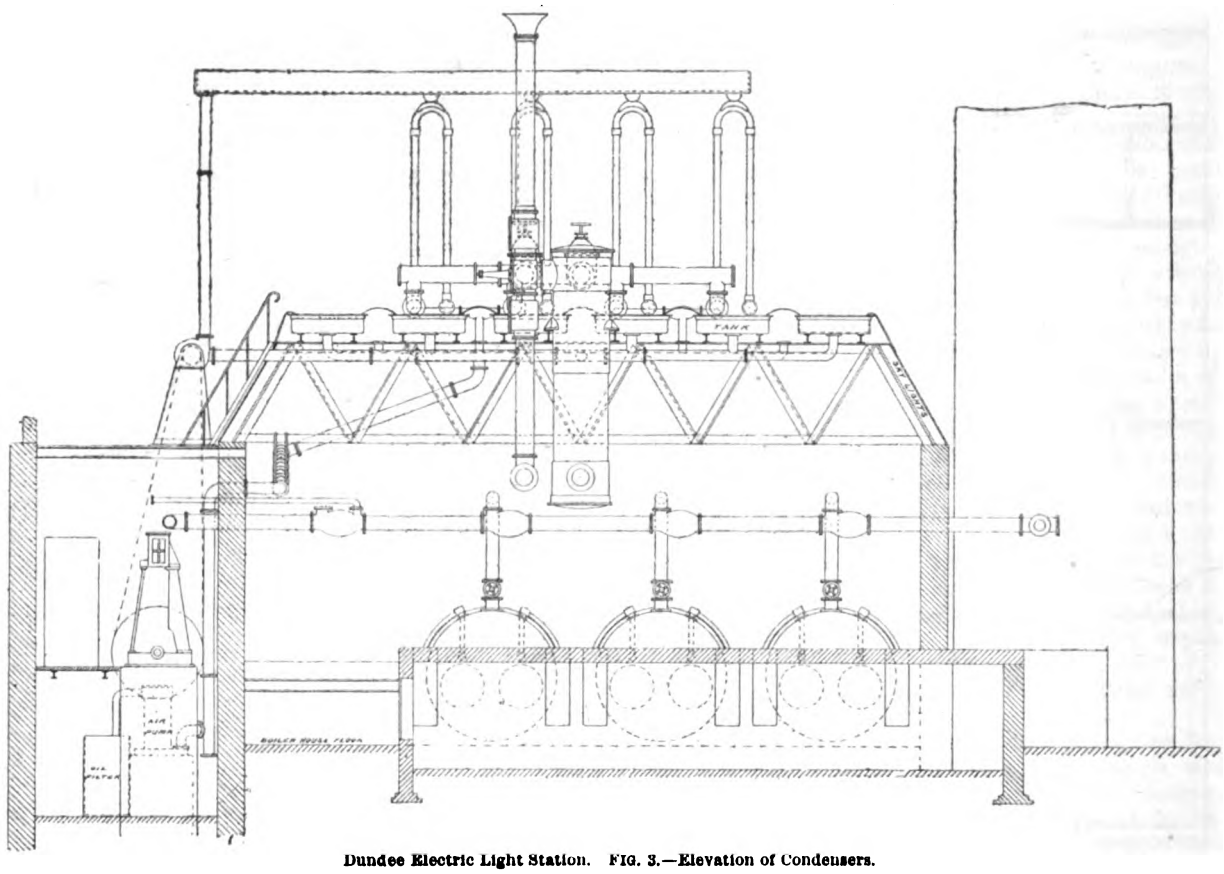


DETAIL OF EXHAUST CONNECTION



TOP OF CONDENSER TUBES
WATER DISTRIBUTION

ELEVATION OF CONDENSERS



Dundee Electric Light Station. FIG. 3.—Elevation of Condensers.

The engines, which have been supplied by Messrs. Willans and Robinson, are six in number—four being H H and two G G. Space is, however, provided for the laying down of two additional engines when necessary. The engines are of the compound type, and can be used either condensing or non-condensing; they are erected on a large block of concrete, 10ft. thick, and only let into the ground a depth of 2ft. Two T branches at the centre of the exhaust main pass on to the boiler-house through the wall. Of these, one is next carried up through the roof, while the other is led to the feed-water heater. The two exhausts are then again joined, there being a valve fixed at the connection, which has been so designed that should the condenser fail and cause the rising in the heater of the back pressure, the steam would escape direct to the air. A tubular heater, hung from the boiler-house roof, is employed. Warren girders have been employed in the construction of the roof of the

from the tanks and delivers it into the gutters on the top of the ∩ tubes. Two small holes are made in the gutter over each ∩. The water escapes through the holes, and runs down on to the outside of the ∩'s, the brackets supporting the gutter distributing it over the surface.

As already stated, there are two spare tanks on the roof. These have been provided in view of future extensions. At present the condenser has a capacity for dealing with steam from engines of 540 i.h.p., more than double the existing capacity of the station.

A vertical compound engine, with 7in. and 13½in. cylinders, drives the air-pumps. Messrs. Whyte and Cooper, of Dundee, made the engine, the condensing plant, and the steam-mains. There are two air-pumps, of 18in. diameter and 12in. stroke. The engine and pumps are coupled direct. All the water before being returned to the boiler is filtered to get rid of oil.

The dynamos have been made by Messrs Siemens

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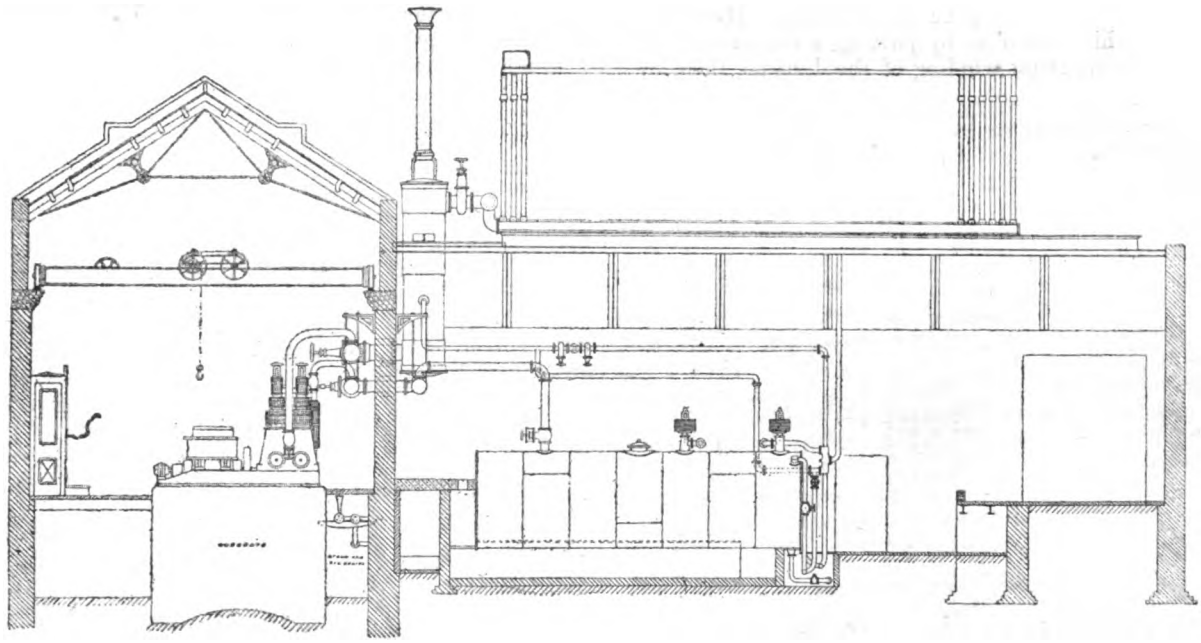
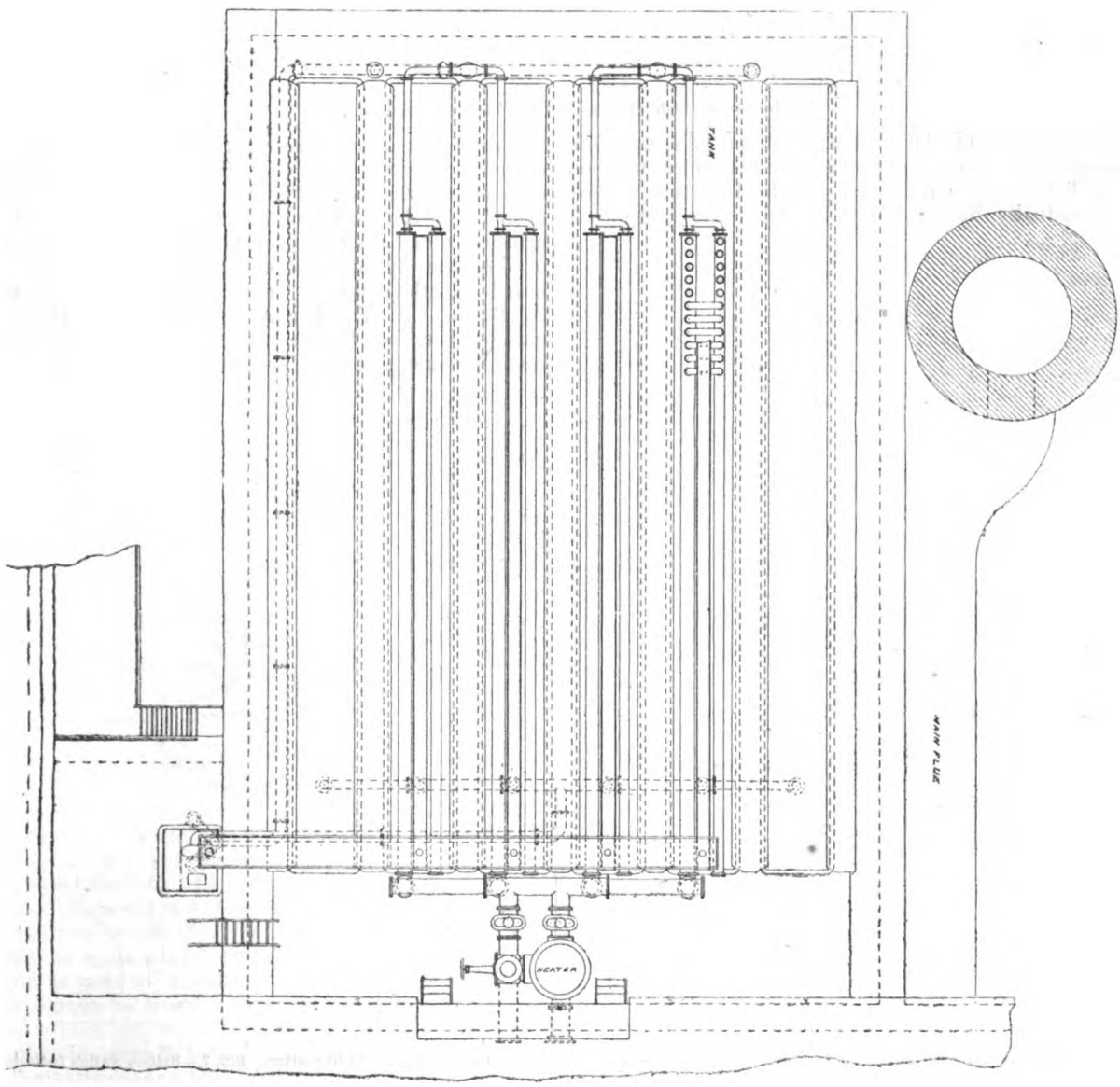
Bros. Four of them are H.B. $^{18}/_{36}$ and two H.B. $^{15}/_{23}$. They are coupled direct to the Willans engines. The machines, at their normal speed of 360 revolutions per minute, give 250 volts, the smaller machines at a normal



Dundee Electric Light Station. FIG. 2.—Cross-section of Engine and Dynamo Room and Boiler House.



PLAN OF CONDENSERS

Dundee Electric Light Station. FIG. 4.—Plan of Condensers.

machines are shunt wound. The four large dynamos have each an output of 87,500 watts. The two smaller machines have each an output of 43,400 watts. The larger speed of 450 revolutions give 140 volts. The shunt of each dynamo is provided with a variable resistance for varying the volts on the machines from 200 to 250 in the

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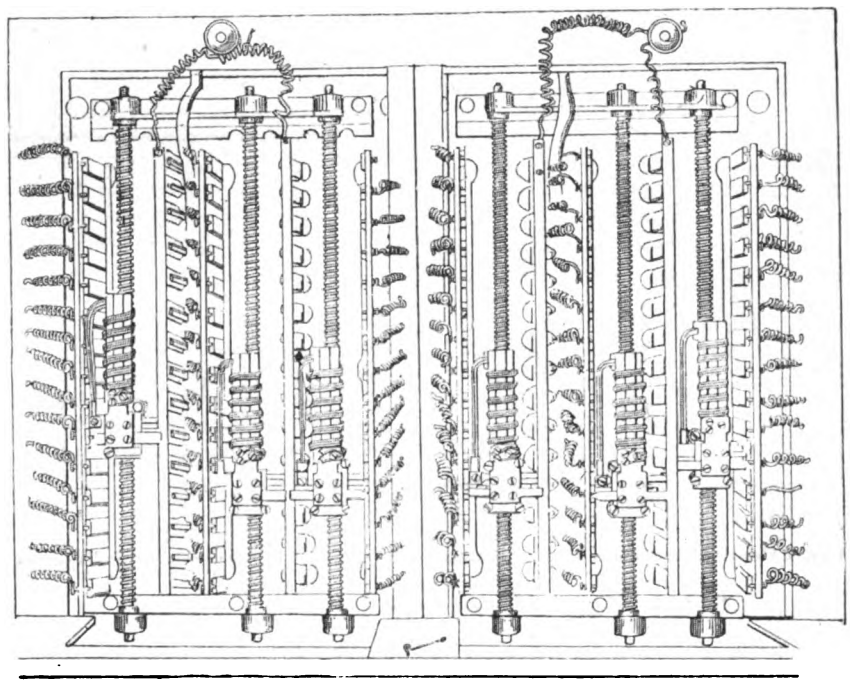
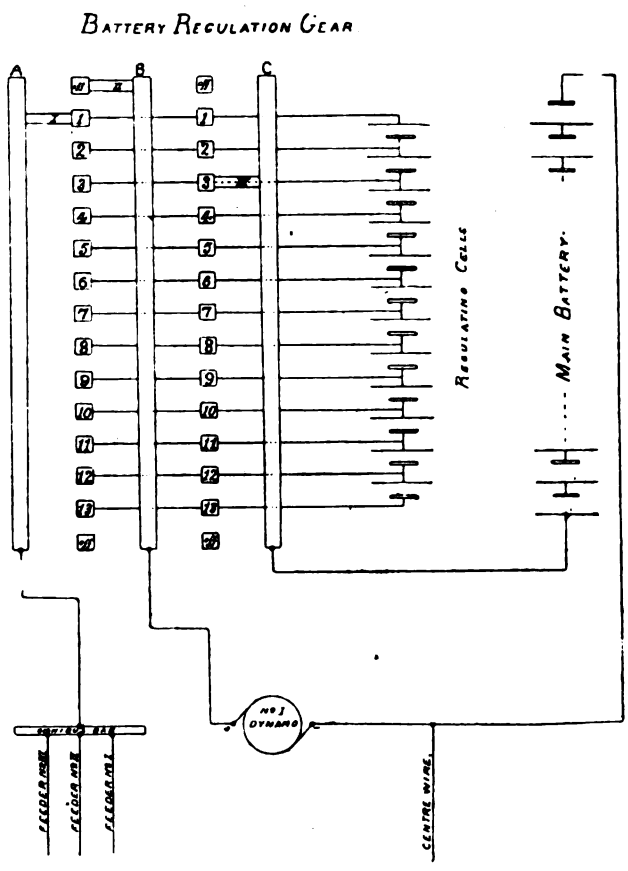
larger machines, and from 100 to 140 in the smaller machines. They are also provided with a Siemens shunt-breaking resistance to avoid breaking down the insulation through suddenly opening the shunt circuit. How this is avoided in this switch is by putting a resistance first in parallel with the shunt winding of the dynamo, then, by a further movement of the switch, breaking the connection with the exciting circuit. This puts the resistance in series with the field coils, round which the field current surges until it gradually dies out. With regard to the connections on the switchboard, the four larger machines supply direct to the outside mains, while the two smaller ones and the batteries are used for balancing.

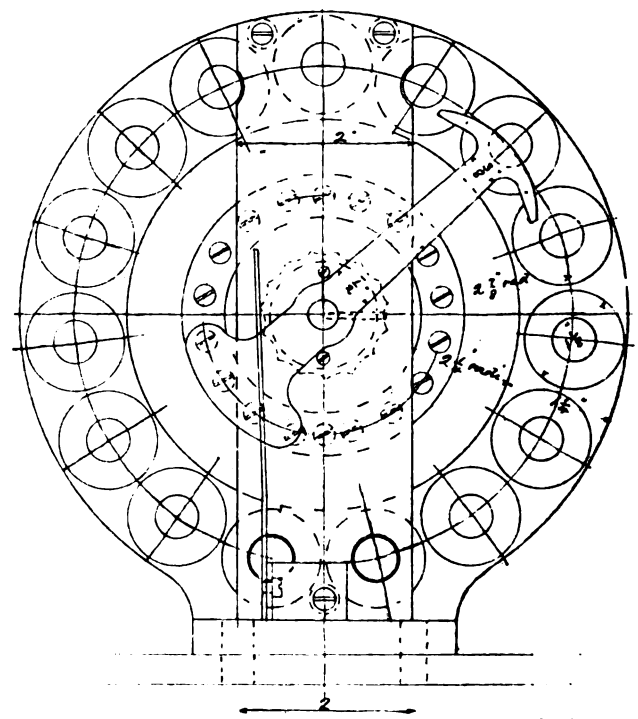


Dundee Electric Light Station. FIG. 6.—Regulating Battery Switch.



Dundee Electric Light Station. FIG. 5.—Battery Regulation Gear.

What is believed to be a new and original method of regulating on the mains, whether the current is being supplied from or to the battery or direct from the dynamos, has been introduced. The regulating cells are entirely detached from the main battery. In order to more clearly explain the principle of this method, we show diagrammatically in Fig. 5 the regulating gear for the positive battery. It will be observed that a switch is provided, consisting of three contact bars with two rows of contacts between them. Each contact is connected to the cells, and two "off" contacts are arranged at each end of the row. The two rows of contacts are connected with the three long contact bars by means of three brushes, which can be moved independently of one another or altogether by means of suitable gearing on the switchboard. In the diagram the long contact bars are marked A, B, and C. The bar A is connected to the positive omnibus bar, bar B direct to the positive terminal of a small dynamo, and bar C to the positive pole of the main battery. The negative pole of the dynamo and battery are connected to the central wire. Dealing with the action of this switch, we will consider that all the brushes are on No. 1 contact, and that the resistance of the two circuits is the same, the counter E.M.F. of the battery being here regarded as a resistance. It



Dundee Electric Light Station. FIG. 7.—Battery Switch Indicator.

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will in this case be obvious that half of the current supplied by the dynamo will pass to the omnibus bar, and half go to the main battery. If now, for the purpose of charging the main battery it is required to raise the E.M.F. on C, and yet A is still required to be kept constant, by lowering brush I. to contact 2, two volts are put in as a counter E.M.F. on the town circuit; the volts on the dynamo must then be raised by altering its shunt, or the volts may be raised before moving the switch. Thus, by lowering brush I. the volts on the battery circuit can be raised to any extent without altering the volts on A. When the battery is fully charged, any more current can be prevented from flowing into it by moving the brush back towards I. and lowering the volts on the dynamo until the volts on dynamo and battery are alike. In this case the dynamo and battery are supplying A in parallel; or it can be done another way—viz., by lowering brushes II. and III. together, at the same time lowering the volts on the dynamo as before. If now it is required to supply the omnibus bar from the battery, the dynamo being shut down, by lowering brush III. until it is on or below I. the battery will be feeding on to the omnibus bar. It will be seen that when brush III. is below I. the regulating cells are in series with and adding their E.M.F. to that of the main battery; and when brush I. is below III. they are in series, but adding a counter E.M.F. It will also be evident that by moving all three brushes together no change in the electrical conditions take place, but that fresh cells are brought into use. One great advantage of this arrangement is that instead of, as in the usual arrangement, only the end cells being used, any of them can be used, and, when required, the charged cells can be used to supply current with the main battery or dynamo, and the discharged cells used where a counter E.M.F. is required in charging, and so a considerable economy can be effected. The regulating battery switch by which these effects are produced has been constructed by Messrs. Johnson and Phillips. It consists of seven enamelled slates, each 6ft. by 3ft. 3in, mounted on a wrought-iron frame. A perspective view of the same is given in Fig. 6. At present there are six feeders, three + and three −, but provision has been made, though at present the instruments are not fixed, for putting in six more. The instruments connected to the two regulating dynamos and the batteries are fixed on the centre slates, the instruments connected with the larger dynamos, and also the distributing bars, being mounted on the outside ones. The voltmeters are of Lord Kelvin's electrostatic type, and the ammeters are by Messrs. Hartmann and Braun. Meters are provided on the batteries, which indicate the current supplied to them, and which deducts the current supplied from them. The gearing for controlling the before-mentioned battery regulating switches, which are fixed on the wall of the battery-room in the basement, is fixed on the board and connected to the switch by shafting and bevel gear.

It is very essential that a brush of the switch should not be left touching two contacts at the same time, as by so doing they would short-circuit a cell. To prevent this happening, indicating gear, shown in Fig. 7, is fixed on the back of the board. It consists of as many small magnets as there are contacts on the switch mounted in a circle. Each magnet is excited by the brush on the switch closing a local circuit. In the centre of each circle of magnets an armature is fixed, to which is connected a pointer which goes through the board to a dial on the front. The attendant on moving the battery switch by the hand-wheel on the board, sees by the movement of the pointer which contact the brush is resting on. The object of indicating the position of the brush electrically is that as the battery switch is some considerable distance from the board, it would be next to impossible to make sure of the position of the brush by trusting to the mechanical gearing, as any wear or back lash would introduce uncertainty as to whether the brushes were in their proper positions or not.

The batteries are the E.P.S. type, and each consists of 48 K-46 cells in glass boxes. The regulating batteries contain 12 cells each, and hospital cells have been provided.

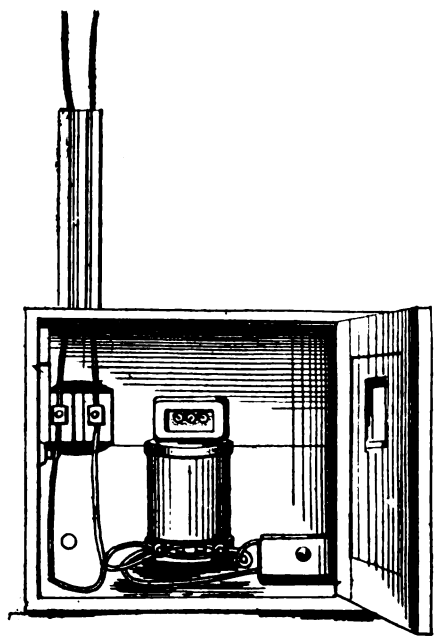
The distributing mains are of vulcanised indiarubber cable, and were supplied by the India Rubber, Gutta Percha, and Telegraph Works Company, Limited. They are laid in wrought-iron pipes under the pavements. All the house connections are vulcanised. The feeders were supplied by the Callenders Bitumen Company, and are of bare copper laid in concrete culverts, great care having been taken to thoroughly drain them.

Under the boiler-house roof has been fixed an artificial resistance capable of absorbing 100,000 watts. It is divided up into sections by a switch for varying the load on it, and is used for testing the dynamos, and to provide an artificial load when the load on the town is very small. Continual records, on self-recording instruments by Richard Frères, are taken of the volts and amperes on the feeders, the volts being taken both at the station and at the point where the feeders join the distributing network. Kelvin standard instruments have also been provided for testing and calibrating the other instruments and for testing meters.

It may be mentioned that the station has been running continuously since it was started on March 15, 1893, and the current sold up to December 31 last reached 66,238 units. Since then a large number of additional lamps has been connected to the mains. We must not omit to state that Messrs. Urquhart and Small, of 17, Victoria-street, S.W., were the consulting engineers for the Dundee Gas Commission in the carrying out of this station, and we are indebted to them for the accompanying illustrations.

A METER-BOX ARRANGEMENT ADOPTED BY THE CORPORATION OF HULL.

There are several reasons, not to mention conveniences, why it is advisable to thoroughly protect electricity supply meters which are fixed on the premises of a consumer, and which are intended to register the amount of supply. What these reasons are it is neither necessary nor wise to explain, and for the purposes of this description they may be considered as already admitted. Every manager of an electricity supply company will very readily appreciate the advantages to be gained by the arrangement which is shown in the accompanying illustration. He



will doubtless understand the advisability of keeping an intelligent public from that little knowledge of electricity which is apt to be a very dangerous thing as far as the interests of the supply company are concerned. Moreover, reasons for protection also apply to the consumers' terminals and to the company's main fuse, and on the low-tension system, which is the system at Hull, it has been found convenient to place these fittings, together with the meter, in one case. The illustrations show the case open. When closed, the record can easily be read through a small glass window in the door.

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The case is sealed up with a wire and a lead seal. In this arrangement no part of the main cables is exposed, and the casing containing them may also be sealed if desired. The idea of this combination originated with Mr. James Piggott, who is the outdoor superintendent and meter inspector of the Electric Lighting Committee of the Hull Corporation.

INSTITUTION OF MECHANICAL ENGINEERS.

ADDRESS BY THE PRESIDENT, PROF. ALEXANDER B. W. KENNEDY, LL.D., F.R.S.

It is a well-known difference between engineering practice in this country and in most others that the conditions of our work seldom allow us to carry specialisation to any such great extent as is common, for instance, all over the Continent. With us the belief that a man is "a thorough practical engineer"—whatever that may mean—is very generally taken as evidence that it is safe to ask him to do anything whatever which may be included within the vague general term "engineering." Of the extent to which this feeling is carried, as well as—I must say—of the essential truth which lies at the bottom of it, no better illustration could possibly be found than the position now held, with so much advantage to the public service, by my distinguished predecessor in this chair, Dr. Anderson. Some of us have occasion to examine continually the epitomised professional histories of engineers who wish to belong to, or to be promoted in, our institutions. It is quite noteworthy in how many cases, especially in our own institution, a man of thirty-five or forty is found to be working with great success in a line totally different from that in which he gained his first experience.

The existence in the minds of the public, who are, in fact, our employers, of the feeling which I have mentioned, no doubt brings us very often into temptation—temptation to undertake work or responsibility in directions where our own common sense only, unaided by past experience, must be our guide. He is a wise man who can tell, as each opportunity presents itself, whether it is really a tide to be taken at its flood, or whether it is one in which his swimming powers will not be sufficient to carry him on to fortune, but may only leave him, and those who trust to him, still short of *terra firma* when the ebb commences. The consideration of this point has probably caused many of us more anxious moments than the actual working out of any of the knotty engineering problems which come upon us after the plunge is taken. I speak in the matter from hard enough experience, for I myself have had all too often to decide such questions, sometimes in one sense and sometimes in the other. So it happens, that having served my time with marine engineers, I have had in the last 25 years to busy myself with half-a-dozen varieties of mechanical and structural work (including what I may call the academic variety during many happy years at University College), and, of late years, also with the newest variety of all—electrical engineering. I trust that my electrical friends—those of them, that is, who are 20 years younger than I am—will forgive me for calling electrical engineering a variety of mechanical work. I mean nothing disrespectful, of course; but even to those who are much more thoroughly electrical engineers than I can ever hope to be, but who have the chronological misfortune, like myself, to have become engineers before technical electricity existed (if I may be allowed so to speak), I think it must always be so To such of us, electrical work has been grafted on to mechanical; and any success we have had in the one, we trace back to its foundation in our knowledge of the other. And further—although I know that in this I lay myself easily open to an accusation of mere conservatism—I believe that even now the only really safe road to success in electrical work lies through the old routine of mechanical training, modified, of course, by the excellent means for studying the scientific side of the work which now exist in so many directions.

It is common on occasions like the present for the speaker to lay before the members such matters out of his own personal knowledge or research or experience as he thinks may be most generally useful to them, as some small acknowledgment of the honour which he has received at their hands in his election as their president for the year. In thinking how best I could fulfil this honourable obligation and pleasant duty it occurred to me, in connection with the train of thought which I have just put before you, that as I happen by some chance to be the first of your presidents who has been actively connected with electrical work, it might be of interest to you, and possibly also of use to some, if I endeavoured to put before you as clearly as I could the way in which the electrical problem of to-day in this country presents itself when looked at from the mechanical engineer's point of view rather than from the electrician's—in other words, from your point of view and mine.

Practical electrical problems divide themselves probably into three main sections, in which electrical energy is used respectively for (1) lighting; (2) power; (3) physico-chemical processes. The third section—where energy is used for the deposition of metals, for the reduction of chemical compounds, etc.—falls outside my own knowledge. From what I know of the success with which it is being worked, I cannot doubt that it has a great future. But its problems only touch engineering very indirectly as yet, and therefore hardly come within the subject which I have prescribed to myself. In this section may be included, at least for present purposes, the application of electricity to heating. So many active and competent workers are at present engaged on this matter that it is greatly to be hoped that success may soon atend their work. Not only the difficulty of producing the heat, but also that of producing it in a convenient fashion, have been overcome to a very large extent. The remaining difficulty is the purely commercial one of producing the heat sufficiently cheaply to allow of its general use. This, I am afraid, has not yet been overcome; and until it has been, electrical heating unfortunately hardly comes within our ken except for very special purposes. Remembering that something like 95 per cent. of all the energy that goes to incandescent lamps appears only as heat, and not as light, there appears to be an ample opening here for another "thermal storage" process, at least, until the present lamps are superseded by the less wasteful type which the future will doubtless reveal to us in good time

The use of electrical energy for power—*i.e.*, for transformation into mechanical energy—is a matter which lies obviously in the closest possible connection with mechanical engineering. It divides itself broadly into three sections—viz., (1) transmission from a distance for whatever purpose; (2) transmission to a number of isolated points comparatively near together, as the tools in a factory; and (3) transmission for the purposes of traction on railways or tramways. The transmission comes in in every case because we have as yet no electric prime mover analogous to a steam-engine. The electric motor presupposes the existence of a dynamo, which must itself be driven by some prime mover. From the dynamo to the motor, whether near or far apart, there must always be transmission of electrical energy. In a recent extraordinary aberration it seems to have been discovered that there was some positive advantage in using steam-engine. dynamo, and motor all in one place to do work hitherto done by the steam-engine alone. This wonderful locomotive. however, forms, and no doubt will continue to form, a class by itself! As to the transmission of power from a distance I shall not say anything, mainly because I could say nothing so well as it has quite lately been said by Prof. Unwin in his Howard lectures. The whole matter is there discussed with so unusual a combination of impartiality, scientific accuracy, and mechanical common sense as to make the lectures, short as they are, into one of the most important contributions to engineering literature which have appeared in this country for a very long time. In particular, one cannot help being struck with the judicial way in which the author has kept clear of the fatal fascination which this matter possesses over many minds otherwise sane—a fascination which in some cases goes so far that one finds the whole matter discussed, perhaps unconsciously, on the basis that it is a positive advantage to transmit power from the longest possible distance! There are several towns in the United Kingdom where the use of water power for the purpose of electric lighting will have some day to be seriously considered, but I hardly think that beyond these the present generation is likely to see any great development in this direction at home. In other parts of the world the conditions are, of course, very different, and English engineers who wish to secure their share of work in this direction will rather have to study it beyond the limits of their own country.

The question of driving the tools in a factory by electric motors instead of through countershafting is one which has recently come to the front. The carrying out of such work is obviously purely a matter of mechanical engineering. Its advisability in any particular case is partly a question of economy and partly one of convenience, and is undoubtedly dependent on the conditions of each particular case. I have found from information very kindly given me by several large engineering firms, that the actual cost to them of power, including coal, stores, wages, and depreciation, generally lies between 2 and 5 per cent. of their total costs. In any given factory running on the ordinary system there is a large continuous waste of power due to the running of the whole shafting, no matter how many or how few machines are at work. Under such conditions the waste work in shafts and belts may well be even 25 per cent. of the average useful work, and the distribution of total work may be approximately:

	H.P.
Average useful work	100
Wasted in belts and shafting	25
Wasted in engine friction, the engine being supposed large enough to give 150 h.p. at tools as a maximum (at about 10 per cent. of maximum horse-power)	20
	145

Now, if all the machines in such a case were driven by separate motors, each having an electrical efficiency of 88 per cent., and these motors worked from a dynamo having an efficiency of 92 per cent. (both of which are high figures for ordinary work at two-thirds output), the figures would stand as folllows:

	H.P.
Average useful work	100
Wasted in motors and dynamo	24
Wasted in leads (say 2 per cent.)	2
Wasted in engine friction (as above)	20
	146

It will be seen that the two sets of figures are practically the same as to amount of power required. As the electrical efficiencies which I have assumed are not likely to be exceeded, I think it may be said that there is no saving to be obtained in horse-power, and none, therefore, in any of the items of cost directly dependent on horse-power, in cases where the power wasted in shafting and belts does not exceed 25 per cent. of the whole average useful

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power. This is a ratio which any engineer can most readily obtain for himself if he is not afflicted with that sense of the insuperable difficulty of making any simple and exact experiment which still remains one of the obscure diseases of our profession. I have no no doubt cases can be found where the waste in large factories with very widely distributed power is very much greater than the proportion assumed, and in such cases no doubt a saving in power costs would occur.

But at the root of the matter there probably lies one ultimate determining point, far too often neglected in such calculations as I have just been making. This point is, of course, the real absolute saving to be made as distinguished from the proportionate saving. It is of little use to show an engineer that he can make even 20 per cent. saving in some one item of expenditure if that whole item only represents 3 or 4 per cent. of his costs, and if at the same time he has to expend a considerable amount of capital in making the change. One does not make important and expensive changes, especially changes whose result is by no means very certainly to be predicted, to bring about an estimated saving of ½ or 1 per cent. in one's total expenditure. I fear that this is a matter which may prove a more serious difficulty in the way of the success of the great Niagara scheme than any of those described by Prof. Forbes. In reference to our present point, it will prove sufficient to prevent the adoption of isolated motors in engineer's works in all cases except where the waste in belt and shaft transmission is exceptionally great, or where for other reasons electrical driving *per se* is desirable. For the whole matter is certainly not concluded either one way or the other by this single consideration. There can be no doubt, on the one hand, of the practical convenience of getting rid of the huge mass of shafting, gearing, and belting which fills up the upper half of many engineers' shops, although it is difficult to fix any money value for this advantage. There is no doubt also that a properly-arranged motor may give a much larger range of speed to each tool than can be readily obtained in the ordinary way, and will thus enable more and better work to be got out of it, with skilful management. Were it not that such magnificent work has often been turned out in this country from such dirty and apparently disorderly shops, I should also say that it was self-evident that every change which improved the general orderliness and tidiness of the shop must—reacting upon the men employed—improve the output both in quantity and quality. Under the actual circumstances one hesitates to be dogmatic on this point, but I incline to believe that it is true, and that the good work to which I have referred has been turned out in despite of its environment, and has been due to exceptional excellence in workmen or managers or both, and that with the same men it might even have been still better under better working conditions. On the other hand, it has to be pointed out that the cost of dynamo, leads, and motors is very greatly indeed in excess of the cost of shafting in almost every case. It is also hardly certain as yet how the costs of attendance, lubrication, renewals, and repairs to the electrical plant compare with the similar costs in the case of shafts and belting. Probably on the whole they would be less, but no satisfactory data on this point exist.

There arise two special cases which should be mentioned. In cases where electrical energy can be obtained from public mains the comparison is quite different. The working of the printing machines, for instance, in the office of the *Pall Mall Gazette* is carried out electrically, the current being derived from the mains of the Charing Cross and Strand Electric Supply Company. The works in this case get rid of all costs of engines and boilers, with all their many inconveniences, and also gain in space most of the room occupied by their old plant. Moreover, they have a better security against breakdown than they could otherwise very well afford to have without most costly duplication of plant. The matter then becomes simply one in which increased space, convenience, and security are to be balanced against increased cost, and each case has to be considered on its own merits. At present it is not very certain how the engineer supplying the electric energy ought to look at such a case. His chief business is, and will be, to supply energy for lighting purposes. As is sufficiently well known, the demand for lighting energy varies enormously throughout the 24 hours, so that, in fact, a plant which is giving 2,500 h.p. for a couple of hours every day, and which, of course, must be large enough for this purpose, leaving still machines in reserve, will only be giving an average of 350 h.p. taken over the whole week, and not even half this for many hours every day and night. It is, of course, very desirable to increase the load during the hours of light load, and if this could only be done without also increasing its present maximum—that is, without necessitating increase of plant—engineers could afford to sell the additional energy at a very low rate indeed. Unfortunately, the condition I have mentioned is impossible. There will always come hours when, through fog or other special causes, the power load will coincide in time with the lighting load. And even if this were to happen only once or twice a year, the engineer must none the less provide plant for it and keep the plant ready. The case is not met by differential charges at different hours. The plant must be provided all the same, and the additional outlay will not be met by the extra payment for a few hours' work per annum. It may, however, very well be met by the value of the additional work done on 360 days out of 365, at times when otherwise nothing would be done. This point I shall deal with later on.

A second special case occurs when the cost of power forms a very large, instead of a very small, proportion of the whole running costs of the works, and no doubt in several industries this is the case to a very much greater extent than in engineering works. I will ask you particularly to notice that in the case where electrical driving supersedes belts, the work is not done any less directly than before. Between the engine and the tool there stand, in the one case belts and pulleys and shafts twice or thrice repeated, and in the other case dynamo and leads and motor, with or without a small belt from motor or machine. It is quite possible that the actual mechanical efficiency of the belts is greater than that of the two electrical machines and the leads between them. But in the case of the shafts and belts the losses are continually going on whether or not useful work is being done, whereas there are no losses in the motors unless they are actually running and driving tools. This brings the total losses equal in the case I have supposed, and in other cases may make the electrical method more economical. But the change is merely a substitution of one indirect method for another equally indirect method.

In the third great case of electric transmission of power, for the purpose, namely, of driving trains or tramcars, we have a state of affairs which is entirely different, and which, I am afraid, is by no means so favourable to the use of electricity as is sometimes supposed. In the case of a train drawn by an engine in the usual way, we have the whole of the net power of the engine, exclusive of that spent in internal friction and in actually hauling itself along—say 80 per cent. of the gross indicated horse-power—available for pulling its load along the line. In the case of an electric railway we have truly a somewhat lighter locomotive to be moved, but against this advantage and the fact that a stationary engine can have a greater economy than a locomotive, we have the uncomfortable state of affairs that only some 35 per cent. of the whole indicated horse-power, as against 80 per cent., is available for the useful work of pulling the train. It seems, moreover, hardly likely that this low percentage will be much increased. The cause of the loss is, of course, the extreme indirectness of the process—that is, the very great number of transformations through which the energy has to pass, in each of which there is always a loss. We may take the figures approximately somewhat thus, always remembering that the average power would be less, probably very much less, than three-quarters of the full power of the plant at work :

	Per cent.
Mechanical efficiency of engine	85
Efficiency of belt driving (if employed)	94
Efficiency of dynamo	90
Efficiency of line	85
Efficiency of motors	85
Efficiency of gearing on locomotives	75
Total efficiency, per cent.	39

From this is to be deducted, say, 10 per cent. for driving the locomotive, leaving 35 per cent. for pulling the train. I think it may fairly be said that to a mechanical engineer the greatest enemy to all economy is frequency of transformation, and that it is, or ought to be, a fundamental rule in all engineering work that every unnecessary transformation, whether mechanical or electrical, should be avoided. Notwithstanding this terrible drawback, the absence of foul gases is of such overwhelmingly great importance in some cases that the working of the City and South London line has only been possible at all because electricity has been employed instead of steam. This, of course, is a case where mere economy of power was not the only or even the most essential thing sought for. In the Liverpool Overhead Railway, also, the conditions of the case rendered the use of steam locomotives impossible, as the line runs along a route on which they are prohibited. The case of tram lines along streets differs altogether from that of an underground or indeed any other railway. Here the steam-engine with its boiler is a bulky and objectionable affair, very apt to cause smoke and other disagreeables, and very unsuitable for trains which consist of one vehicle only, weighing less than its locomotive would have to weigh. I have often wondered why the Serpollet boiler and engine have not been introduced for tram work. They take so little space that they might very possibly be put on the car itself (the car being made reversible as at Manchester), but I suppose some difficulties have been found ; at any rate the proposal has not been made, so far as I know. But apart from this, and not forgetting the steam cars which are actually at work in certain places in the North, there is probably no form of steam car which would be generally endured by the public. Here, again, therefore, electricity would appear to come in regardless of cost, in the same way as with the underground railway, although for another reason. But here we are met at once with the mechanical difficulty (not existing, of course, in the tunnel or on the overhead railway) of getting the current to the motors on the car. In America the knot is cut, rather than untied, by the use of overhead wires, and in country places it is probable that this may be here the best solution of the problem. But in our cities, where the bulk of the tramway traffic of the country is really carried on, I am still conservative enough to think, and also to hope, that this is impossible. Without forgetting the much-quoted case of Budapest, therefore, I fear that the introduction of electricity for car-driving in this country will still wait until a practicable underground system has been devised. Meanwhile it is being hard pressed by its rivals—cable and compressed gas. Of the two I think the latter, although the younger, is far the more formidable. It has the advantage of being even more direct than a steam-engine (the boiler being absent) ; it can be applied to each individual car even more easily than an electrical motor, and it enables the car to run freely on ordinary lines without their reconstruction, and without any mains either above or below ground. It has as yet had but short trial, but what I have seen of it makes me sanguine as to its ultimate possibilities.

Before speaking more particularly about the mechanical aspect of electric lighting problems, I feel bound to touch upon a matter

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which arises directly out of the question of supplying electric energy for power and for light concurrently, to which I have just drawn attention. It is a favourite bit of cheap criticism indulged in by those who have not to supply energy on a large scale at the expense of those who have, that the former class of folk show their ignorance of their own work and interests by neglecting to obtain that enormous demand for motive power which would come on them if only they reduced their prices low enough. The criticism is really as absurd as that other which censures the gas companies because they do not supply heating gas at a few pence per thousand feet, which apparently they would be perfectly able to do if only they knew their own business half as well as their critics do! In both cases the criticism is mere words, "signifying nothing." We have simply to remember the fact that the mere possibility of driving something by electricity does not of itself create the things that want to be driven. There are isolated districts in London—Clerkenwell, for instance, and the neighbourhood of Fleet-street—in which there is a considerable amount of power of a kind which might be furnished electrically if the cost were made sufficiently low. In most parts, however, the whole energy expended in doing mechanical work is but a very small percentage indeed of the energy required for light, and it would not be increased in the least even if it were supplied for nothing. When the inhabitants of Mayfair and Kensington, for instance—to take these districts only as typical of many others—take to brushing their boots, washing their faces, and serving their meals by electricity, a demand will have arisen which may perhaps be fostered into something worth considering. Until this happy state of affairs comes about, I fear that the demand for motive power in English residential and semi-residential districts must remain a factor practically negligible in the calculations of the engineer. Whether in a purely manufacturing district it may ever be found to pay to put down a central power station and transmit power to factories, each of which would replace its steam-engine and boiler by an electric motor, is a question about which there is a good deal to be said on both sides. I have already indicated the lines along which I believe this matter will settle itself.

I pass now to the last and largest section of my subject, the question of public electric lighting from the point of view of the mechanical engineer. From the side of the public—that is, of the users of electric light—the essential points are simple—viz., that the light should not visibly flicker, that it should not be below the declared pressure nor very much above it, that it should be available at all hours, and, of course, most of all, that it should never go out. But any notions one might have that in consequence of the simplicity of this final result the means of attaining it would also be simple, are very speedily dispelled by a consideration of the facts. It is, alas! not sufficient to provide a shed, a boiler, a decently-governed engine, and a dynamo and alternator, and many and sad have been the disappointments in consequence. The fact is that although the final result to be attained is always the same, and is always extremely simple and straightforward, the conditions under which that result has to be obtained are always varying, and are not only extremely complex in any one place, but are also different altogether in each different place. To members of this institution, however, I need not point out that this is not any cause for grumbling—the more difficult and complicated the problem, the more chance there is for the engineer in working out its solution. I will consider first those variations which are entirely beyond the control of the engineer—*i.e.*, the variations of load—and afterwards those which are within his power—*i.e.*, variations in the working of the station. To those of you who have practically to do with these matters the variations I have to speak of are absurdly familiar, but to others—probably the majority—they are still sufficiently unfamiliar to be of some little interest. I have therefore prepared diagrams which may illustrate them.

Diagram 1 shows the variations of output of a lighting station during a whole year. Each vertical division stands for one week. Irregularities are due to particularly foggy weeks, or to weeks in which public holidays occur, such as Easter and Whitsuntide. For the rest the curve follows pretty obviously the changes in daylight, except that the minimum occurs not in the very middle of the summer, but during August, in consequence of the large number of private houses which are shut up at that time, while the days are still too long to require the use of any artificial light in shops which close at 7 o'clock. Diagram 2 shows the variations within a week, each vertical division standing for one day. Here, of course, the chief variation is that which occurs on Saturday and Sunday. Diagram 3 shows the variations occurring within one day, the vertical divisions each standing for one hour. In this diagram three days are actually shown, one in December, one in August, and one in June, and it will be noticed that the three are very different. In winter there is practically always a double maximum, one occurring about breakfast time or in the forenoon, after which the load falls off in the middle of the day and reaches its full maximum towards evening. In the summer time the morning load disappears altogether, and there is only one maximum, which occurs much later than it does in winter. In fact I have noticed that in London, at any rate, the average time up to which people use light is fully an hour later in the summer than it is in the winter, a somewhat interesting fact in sociology. In August the "peak" of the diagram becomes a minimum, the private houses using no light because they are closed, the shops because the days are still too long. The red line on Diagram 1 shows in rather an interesting fashion that the maximum load and the maximum output by no means vary together. The maximum load is much more constant than the maximum output, and does not vary nearly so fast or so much. The quantity which chiefly varies is the time during which that load lasts, and this time is, of course, dependent on the hours of sunlight, or more particularly on the interval between sunset and closing or bedtime.

Besides the variations shown in these diagrams it is right that I should mention one or two others. A very important class of variations are those which may be said to be due to latitude. In a place as far north as Aberdeen, for instance, there is practically no night for two months in the year, and for a much longer time than this no lighting whatever is used in shops, and hardly any in private houses. On the other hand, the hours of lighting in the winter are proportionately longer than in the South. The effect upon the annual output diagram would be not to alter its area considerably, but to thicken it up in the winter and reduce it very much in the summer. As an illustration of northern loads I have shown in Diagram 4 load curves for a winter and a summer day, taken at a little station which was running in Glasgow supplying offices some two years ago. One set of variations which puzzles and troubles the engineer very much is the varying amount of light thought necessary by people in different parts of the country. No doubt this depends to a considerable extent upon the nature of the premises in which the light is used, but even this is hardly sufficient to explain the whole of it. In a purely residential district in London, for instance, the average energy used per annum is only about 12 units per lamp wired. In a mixed district, like that of the Westminster Company, it is about 16 units per lamp wired. In a very rich district containing many clubs, like that of the St. James's Company, one is not surprised to find that it amounts to 22 units per lamp wired. But one is on the whole surprised to find that in Newcastle it should be as much as 25 units, and in Leeds 27. It is no doubt with less surprise that one notices that the consumption of 38 units per lamp which existed in Exeter when current was paid for by contract, and not by meter, was exactly halved as soon as consumers were made to pay for the amount which they really used.

There is one set of variations which, unlike all those which have been mentioned above, is to a certain extent under the control of the engineer—I mean the variations on the two sides of a circuit which is arranged upon a three-wire system. Here, of course, the engineer in the first instance endeavours to connect about the same number of lamps wired on each side of his system, and to see that the balance is approximately right, not only over the whole system but over each small section of it. In spite of all the care that may be used in this matter, however, I have found that a three-wire system may be very often greatly out of balance for a few minutes at a time owing to causes entirely beyond the engineer's control. Rapid changes in this respect occur chiefly within the 15 or 20 minutes during which load is coming on most rapidly in the afternoon. In a station when the load was increasing from 2,000 up to 8,000 amperes I have frequently seen that in the course of 10 minutes first the positive and then the negative side would have 400 or 500 amperes more than the other. By the use of a balancing machine, which can be transferred by a single switch from one side to the other, the case, of course, can be met as it arises, but it is sometimes a little surprising that the changes should be so large and so rapid. I have endeavoured to indicate to you some of the great number of variations in conditions in spite of which the engineer has to obtain a uniform result. All these variations, even the last, are practically altogether beyond his control. Some of them occur with considerable regularity and can be foreseen, others are most irregular and come without any warning whatever. But all of them affect very greatly both the method and the cost of production. The method first, because the efficiency and regularity of supply must be considered before the matter of economy. Any method of supply which was inevitably liable to breakdowns and interruptions would be wholly condemned on that ground alone, even if it happened to be of the very highest economy. But given any one of the many methods of supply which are equally good as to result to the consumer, then that method must mainly be judged by its economy under the particular conditions in which it has to work. It will, of course, be borne in mind that the cost of power production in this case is not a mere 3 or 4 per cent., as in the case of a factory. It is 50 or 60 or 70 per cent. of the whole expenses, the balance being expenses of management and distribution, along with interest, depreciation, and other charges connected with capital.

As to the effect, then, of the uncontrollable variations on system or economy, the first thing which I have to point out is that their madness is not entirely without method. There are some points which are as certain as it is that all members of Parliament will not be on one side, in spite of the fact that such a thing is in imagination conceivable! Two of these are of special importance. First of all, there will never be more than certain proportions of all the lamps which are wired alight at once, either at times of maximum or of minimum load. The maximum maximum on the circuit of the Westminster Company is about 35 per cent., on that of the St. James's Company I believe over 60 per cent., of the House-to-House Company about 35 per cent. In Glasgow, where at present the light is solely in the region of offices and shops, the proportion is as high as 56 per cent. You will see that these proportions depend largely upon the nature of the places where the light is used. This proportion, which, of course, can be only an estimate in any particular place until the experiment is made, fixes for the engineer the maximum number of lamps wired for which a given horse-power will supply current. The maximum minimum is an almost equally important quantity, and in most places the engineer has to do with two such maxima, one for the day hours and another for the night. In a purely residential district the night load will always be very small, and the day load will be practically nil. In the City of London the day load, in consequence of the number of dark places to

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be lit, is considerable, the night load extremely small. In a mixed district like that of the Westminster Company, the day load in the middle of the summer is not greatly more than the night load. It is to be noted, however, that the night load is practically the same all the year round, while the day load, even apart from fogs or exceptional weather, necessarily varies very much. The maximum maximum, also, as we have seen, varies very much at different times during the year, although it never exceeds a certain amount. It is also worth noticing that, in general, the night load on a central station will increase but slowly with the growth of the station. The first consumers who take the light are most often those who are most in need of it, who require it for dark corridors and long hours. Later on, thousands of lamps may come on to a circuit in shops, offices, and in ordinary private houses, without a single one of them being used after midnight. In an average district the day load increases faster than the night load, because out of any large number of shops and offices some are sure to have dark places requiring current in the daytime. But neither night nor day loads increase nearly as fast as the maximum evening load, which—a certain normal condition having once been reached—will increase exactly in proportion to the lamps wired. In an alternating-current station, where very numerous isolated transformers are used, the night load increases nearly proportionately to the day load because of the increase of magnetising current.

The determination of the sizes of units to be used in any station depends essentially on the probable values, absolute and proportionate, of the loads I have mentioned. It is now a commonplace, although a few years since no one seems to have thought of it, that the machinery in a station should be so subdivided that under all sets of conditions which remain steady for a few hours at a time it should be possible to have such machinery as is running, running more or less nearly full loaded—only in this way can much economy be hoped for. It must not be taken, however, that this is a mere question of arithmetic which can readily be settled off-hand. In every case—it is to be hoped—the output of a station will be much greater 10 years hence than it is to-day. The engineer has not uncommonly to consider somewhat difficult *pros* and *cons.* when he is called upon to provide machinery which shall be of such a type that it can allow dividends to be earned during the years of growth and yet remain still suitable in the time of maturity. It is further to be remembered that this question of the choice of size of unit is also quite modified in the cases where condensing plant is used instead of non-condensing. The reasons for this I will not discuss here; I had a good deal to say about them in a recent discussion at the Institution of Civil Engineers. A good condensing engine uses nearly the same steam per indicated horse-power hour at any load above half output. The increased consumption per electrical horse-power hour is therefore proportionately much less than in the case of non-condensing engines, and the economical importance of fully loading the machines is correspondingly minimised in stations where condensing plant is employed. The question of size of unit leads naturally to that of the necessary magnitude of reserve in any case. I think this is a simple matter, but no doubt it is sometimes wrongly treated. To make the reserve a fixed proportion to the total plant, for instance, is a method which can only possibly come right by a fluke. I will not argue for the necessity of a reserve—that appears to me to be beyond any argument. The reserve is required for two purposes—to provide against breakdown of plant and to provide against accidental increase of load on special occasions. It is in the primary conditions of the case that the light absolutely must never go out, even if a machine wholly breaks down at the time of full load. From this it follows as a mere matter of arithmetic that the minimum of reserve must be a unit equal in size to the largest unit in the station, so as to be capable of taking its place if it breaks down. I should have thought that it went without saying that a machine of 100 h.p. could not be a reserve in a station where other machines were of 200 h.p., had it not been that I have seen it often so said. If an engineer considers that the winter, when the full load is liable to come on at any moment, is a suitable time for overhauling his plant, it is obvious that the reserve must be at least double the minimum which I have mentioned. Indeed, most engineers would prefer to have two strings to their bow, and not to know that the breakdown of one machine would absolutely use up the reserve they wanted to keep in case of specially heavy load coming on, as long as it (the breakdown) lasted. This, however, is a question of degree, of caution, and some would say also of nervousness.

Those questions about the running of a lighting station which are essentially matters of mechanical engineering group themselves mainly in three sections, according as they relate to (1) security, (2) efficiency of regulation, and (3) economy of working. It is obvious that the fundamental question of the choice of an electrical system in any particular case connects itself with all three, but this fundamental question I do not propose to discuss here, partly because it is not a matter which can be discussed in a few words, and partly because it is to so very large an extent an electrical matter that it does not fall well within the scope of my present address. Of the three points I have put security first, because no doubt the absolute certainty that nothing short of a boiler explosion, or of the burning down of a station, shall stop the supply of current is really the very first condition of supply. Clearly with any machinery the burning of an armature, the seizing of a bearing, or the breaking of a shaft, are possibilities which may have to be faced at any moment. They seldom occur—very seldom happily—but sooner or later one or other will come about, and the engineer in charge has to be provided with means for preventing any such accident having more than the most transient effect on his light. Of course, the existence of proper reserve plant, such as I have already mentioned, is the first necessity of the case. Scarcely less important, however, is the necessity that such reserve should be almost instantly available. Where all the plant is running in parallel—*i.e.*, where all the dynamos or alternators are working straight through the same pair of omnibus bars on the switchboard—it will very often happen that the other machines which are at work may of themselves be able, at least for a few minutes, to take up the load of the one which has broken down, and so to allow time for another machine to get started. It may quite well happen, however, that these machines may be themselves running very nearly at full load, and that the broken-down machine may have had so large a load upon it that this is impossible. In any case a large machine—say 400 h.p. or more—cannot be started and got on circuit in a few seconds, and seconds are of importance in these cases. For this reason, in stations which use alternating currents it is usual, and probably necessary, to have one reserve machine always warmed up and running round at half speed, so that it is merely a matter of opening a stop-valve to let it away in a condition ready for putting on circuit, although the synchronising in is unfortunately always a matter which may cause some minutes' delay. In continuous-current stations it frequently happens that a battery is used which can give so high a discharge for four or five minutes as to take the place—along with the machines remaining on circuit—of the machine which has given way, until another machine has been started and put on. So far as it goes this is no doubt a great advantage, but it must be remembered that the mere existence of a battery, and even of a battery quite sufficient for helping in day and night light loads, is not sufficient to ensure that the battery shall be available for help in this fashion. Two details are easily seen to be essential when it is remembered that the failure may occur during the hours of full load. As the volts are highest at such a time, the battery must not only have sufficient capacity but also must have a sufficient number of cells to give in discharge the full E.M.F. of the station, and this will not be the case unless the engineer has specially provided for it by an unusually ample number of cells. Secondly, the battery must have been fully charged beforehand so as to have the maximum E.M F. per cell available. This involves that the battery charge should have been completed during the day, before the hour at which full volts could possibly be required from it in case of any accident. A battery which could only discharge heavily at 215 volts would be practically no use whatever as security against a drop of pressure after an accident which might possibly occur at 230 volts.

In an alternating-current station where the machines are not run in parallel, but where each alternator supplies current to its own separate circuit or bunch of circuits, the sudden failure of a machine must instantly cause extinction of light in the circuit affected for the fraction of a minute which must elapse before the circuit can be thrown on to other machines, or the few minutes which it must take to get another engine started and plugged on. In a station worked on this plan, however, the machine which is turning round as stand-by can be kept excited and giving the volts corresponding to its speed, and can be plugged on in readiness, so that the circuit from any machine which has broken down can be instantaneously switched on to it and it can be run up at once to full E M.F. without, of course, any of the delay which would be unavoidable if it had to be synchronised and put in parallel. It has also to be borne in mind that in cases where a number of alternators are running in parallel the breakdown of one may tend directly, in certain cases, to endanger all the others—a trouble which does not exist if circuiting be used. On the other hand, the circuiting system causes inevitable, if slight, flickers in the light, which are quite avoided by running in parallel. It also necessitates the use of comparatively numerous circuits, as no one can be allowed to carry more than from 30 to 50 kilowatts at a time when it is switched on or off. It must be recognised that in one matter the requirements of security and of economy are more or less opposed. If an engineer is quite certain that, whether by the help of batteries or otherwise, he can bring his reserve into action so promptly that the worst breakdown will not spoil his lighting, he will no doubt always run each unit of his plant at nearly as its full capacity as possible. But if for any reason he cannot be so sure of his reserve, he will gain greatly in security by running his plant always so far under its maximum that he can distribute the load of any one unit for a few minutes over the others without endangering them. But, of course, this is practically equivalent to under-rating the whole capacity of the plant by a considerable percentage, probably 20 per cent., and consequently of increasing the capital cost of the plant per unit of normal maximum output by just the same percentage—a result which one does not wish to face.

(To be continued.)

PHYSICAL SOCIETY.

At a meeting of this society on the 13th inst., Prof. A. W. Rücker, F.R.S., president, in the chair, Mr. W. G. Rhodes, M.Sc., was elected a member of the society.

The **President** invited discussion on Prof. Henrici's paper on calculating machines, and said a description of Mr. Sharp's harmonic analyser, giving direct readings of the amplitude and epoch of the various constituents simple of harmonic terms, had been sent in. This machine requires no adjustments to be made before using. The amplitude is given by the length of a line joining the initial and final positions of the point of contact of a roller with a rotating disc, whilst the epoch is determined by the

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angle which this line makes with the plane of the roller in its initial position. **Prof. Perry** congratulated Prof. Henrici on the success attained with his analysers. Referring to planimeters, he said the average error made in working out indicator diagrams with Hine and Robertson's instrument was only about one-third that made with Amsler's. After pointing out the great importance of Fourier's series to practical men, and especially to electrical engineers, he said that in studying reciprocating motions, such as those of pistons, valve gears, etc., it was most useful to resolve the motion into its fundamental harmonic motion and its overtones. In this way remarkable differences would be seen between various motions which have the same fundamental, and which are usually considered equivalent. In 1892 he had published the numerical work for a given periodic curve developed in Fourier's series, and he now exhibited a graphical solution done by one of his students, who was probably the first to carry out the late Prof Clifford's idea of wrapping the curve round a cylinder and projecting it on different planes. Prof. Henrici had, he said, based the construction of his first analyser on Clifford's method, but used the Henrici principle—viz., $\int y \sin\theta\, d = \int \cos\theta\, d\, y$, when integrated over a complete period—to explain the later machines. As a matter of fact, the first machine in which the coefficients were determined by an Amsler planimeter carried by a reciprocating tangent plane was a beautiful example of the Henrici principle, and he, Prof. Perry, saw far greater possibilities before it. The defects in the first instrument were mechanical ones, and could be got over by increasing the amplitude of the harmonic motion. Not only was the machine useful for Fourier expansions, but by giving suitable motions to the tangent plane developments arbitrary functions in spherical harmonics, Bessel functions, Lawe's functions, and other normal forms could be determined. He had designed a machine which, on Prof Henrici's principle, developes arbitrary functions in Bessel's, and hoped to have shown it in working order at the meeting; the Easter holidays had prevented its being finished in time In this machine the motion is given to the table by a cam and roller, the cam being shaped so that the displacement of the table is $x \times J_1(x)$ when the shaft turns through an angle proportional to x. The revolving cylinder is driven by variable gearing from the cam shaft. By using cams of other shapes, developments in many normal forms may be obtained; the machine is therefore of general analytical use. An example of development in Bessel's worked out arithmetically by two of his students (Messrs. Hunt and Fennel) was given, and the process of performing the integrations by the machine described. **Prof. Boys**, speaking of arithmometers, said Prof. Selling's machine had several inconveniences. In the first place, it occupied a large space, and the projecting racks were apt to upset things put behind the machine. Secondly, the result of any operation was indicated by continuous motion, and therefore cannot be read off instantly with certainty. On the other hand, the Brunsviga was very compact and convenient, the only serious defect being that one cannot carry on figures obtained as the result of one operation to work with again, as was possible with the well-known Colmar machine. As another improvement he suggested that the two sets of numbers on the wheels, showing the result of any operation, should be coloured differently, so that it would be easy to see whether multiplication or division had been performed. The labour of operating with large digits could then be considerably reduced with certainty. For example, in multiplying by 2 9 9 8, instead of 28 (2+9+9+8) turns of the handle, five would be sufficient—viz., three in the forward direction and two backward, thus giving 3 0 0 2. In his opinion logarithm tables were not nearly so convenient for ordinary calculations as this machine **Mr. A. P. Trotter** described how, by the use of templates cut to special shapes, one could obtain true curves from those given by recording voltmeters and similar apparatus. **Mr. Yule** said he had recently seen the newest analyser made by Coradi for Prof. Weber, and was present when it was tested by the latter on a simple harmonic curve. It gave excellent results, the errors not amounting to one part in 2,000. Speaking of the "hatchet" planimeter, he thought the first one was exhibited by Mr. Goodman at the Institution of Civil Engineers. **Mr. A. Sharp** remarked that since last meeting he had designed an inversion of the mechanism in his harmonic analyser which made it much more practical. **Prof. Henrici**, in reply, said the uses of his first machine suggested by Prof. Perry might lead to great developments in this subject. Lord Kelvin had shown that with the sphere and roller integrator products of two functions, such as $f(x)\, F(x)\, d\, n$, could be got. Referring to Prof. Boys's criticism on the Selling arithmometer, he did not consider the difficulty in reading off the results at all serious. Mr. Trotter's method of solving problems by templates might be very useful. Speaking of the "hatchet" planimeter, he said he believed it was first brought out in Denmark. Mr. F. W. Hill, of the City of London School, had sent him a solution of its action. Mr. Sharp had made a very considerable improvement in his machine, and the elements of this integrator may be useful for other purposes.

Mr. P. L. Gray, B.Sc., A.R.C.S., read a paper "**On the Minimum Temperature of Visibility**," describing experiments made to find the lowest temperature at which bright or blackened platinum becomes visible in the dark. The instrument used was a Wilson and Gray's modification of Toly's meldometer, in which a thin strip of platinum, about 10cm. long and 1cm. wide, is heated by an electric current. The expansion of the strip is indicated by an optical method as used for estimating the temperature of the strip. To calibrate the arrangement, small particles of substances having known melting points were placed on the strip and observed through a microscope, the position of the spot of light showing the expansion being noted when the substance melted. The general conclusions arrived at are: (1) that the minimum temperature of visibility is the same for a bright polished surface as for one covered with lampblack, although the intensity of radiation in the two cases may be different; (2) that the visible limit at the red end of the spectrum varies greatly for a normal eye according to its state of preparation—exposure to bright light diminishes the sensitiveness of the eye and darkness increases it; (3) that for the less sensitive condition the minimum temperature of visibility for the surface of a solid is about 470deg. C., but this may be much reduced by even a few minutes in a dark room; (4) that at night a surface at 410deg. C. is visible, and that by resting the eyes in complete darkness this may be reduced to 370deg. nearly; (5) that different people's eyes differ somewhat in their "minimum temperature of visibility," but probably not to any great extent if tested under the same conditions as to preparation, etc. To most observers the strip at these low temperatures had no appearance of red, but looked like a whitish mist. Inserting a plate of glass or a layer of water in the line of vision had no effect on the temperature of visibility. **Mr. Blakesley** enquired if the author had tried condensing the light from the strip. As to colourlessness, he observed that the parts of the retina active in oblique vision were less sensitive to colour than the central portions. **Dr. Burton** remarked that in the experiments the presence of light, and not colour, was being observed. When illumination was faint, as in twilight or moonlight, it was very difficult to distinguish colours. In the solar spectrum one did not see any whitish termination at the red end. **Mr. Elder** said Captain Abney had shown that all colours appear grey when of small intensity. The **President** thought the question as to whether visibility depends on wave length or on energy was an important one. Probably a minimum amount of energy was essential. At such low temperatures the emission curves of the different wave lengths may not have become sufficiently separated to be distinguished. **Mr. Gray**, in reply, said Prof. Langley had shown that a minimum, but very small, amount of energy was necessary to vision in all parts of the spectrum.

Dr. Burton's paper on "The Mechanism of Electrical Conduction," was postponed.

LEGAL INTELLIGENCE.

IVES AND ANOTHER v. WILLANS.

In the Court of Appeal, on Tuesday, judgment was delivered in the case of Ives and another *v.* Willans. This was the plaintiffs' appeal from the judgment of Mr. Justice Kekewich, staying proceedings in the action and referring the matters in dispute to arbitration. The defendant entered into a contract for the construction of the Liverpool Overhead Railway, and let out certain portions of the work under a sub-contract to the plaintiffs. The original contract contained a clause referring all disputes to three engineers, whose decision was to be final, and no action commenced until the decision of the engineers had been given and this clause embodied in the sub contracts. Disputes arose between the plaintiffs and the defendant. An action was commenced, and the defendant applied to have it referred. The plaintiffs, however, contended that the matter could not be referred to the arbitrators inasmuch as the defendant had taken a step in the action by asking for a statement of claim. Further, they attacked the fairness of the arbitrators, and contended that as the whole of the matters could not be referred, no part of it ought to be Mr Justice Kekewich, however, referred the question to the arbitrators, and this decision, from which the plaintiffs appealed, the Court now upheld, dismissing the appeal with costs.

MEUX'S BREWERY COMPANY, LIMITED, v. THE CITY OF LONDON ELECTRIC LIGHTING COMPANY, LIMITED - SHELFER v. SAME.

These actions were decided last week before Mr. Justice Kekewich in the Chancery Division of the High Court of Justice. The first action was brought by the owners of a public-house to restrain the defendants from working their engines and carrying on their works at Bankside in such a manner as, by vibration or otherwise, to cause damage to the public-house (the Waterman's Arms), or to interfere with the business there of a licensed victualler, or otherwise to cause annoyance, nuisance, and danger to the occupiers of the house. It appeared that close to the Waterman's Arms the defendants had an electric lighting station with powerful steam-engines and dynamos at work, and it was said that the working of the machinery was causing serious injury to the structure of the house and producing unpleasant vibration throughout the house to the annoyance of the occupiers and customers. The second action was brought for a similar purpose by the publican in occupation of the house under a lease granted by the plaintiffs in the first action. On behalf of the defendants it was contended that, in the absence of negligence on their part, they were relieved by their statutory powers from liability to an action for nuisance, and, further, on the evidence, that no actionable nuisance had been shown to exist. It was also argued that, as the plaintiffs in the first action were only reversioners, they had no right to sue in respect of a nuisance which was not necessarily permanent, and might be removed before their interest fell into possession.

Mr. Warmington, Q.C., and Mr. Badcock appeared for the plaintiffs in the first action; Mr. Warmington, Q.C., and Mr. Waggett for the plaintiff in the second action; and Mr. Moulton,

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Q.C., Mr. Renshaw, Q.C., and Mr. W. C. Braithwaite for the defendants in both actions.

Mr. Justice Kekewich, upon the construction of the statutes and provisional order under which the defendants were constituted, were of opinion that they was not thereby relieved from liability to an action for nuisance. His Lordship further held upon the evidence that it had been proved that, by reason of the working of the defendants' engines, injury was caused to the premises in question by vibration and noise, and also, in some degree, structurally. Having regard to the manifest inconvenience which would result to the inhabitants of the district which the defendants supplied with electricity if their works were stopped, his Lordship did not think fit to grant an injunction. The plaintiff lessee was, however, entitled to enquiries as to the damages caused to him as such lessee by vibration, noise, and structural injury, and to the costs of the action, and there must be judgment to that effect. As regarded the other plaintiffs, their action so far as it claimed an injunction must be dismissed with costs, it being clear upon the authorities that, being reversioners, they were not entitled to relief by injunction in a case such as the present. They were, however, entitled to an enquiry as to any damage done to the inheritance, but the costs of such enquiry must be reserved.

EBBSMITH v. DAWSON AND OTHERS.

The hearing of this action, the details of which were published in our last issue, was concluded on the 19th inst. before the Lord Chief Justice and a special jury in the Queen's Bench Division of the High Court of Justice. It will be recollected that the plaintiff, Mr. Joseph Ebbsmith, sued the defendants, who were members of a shareholders' committee of the South Staffordshire Tramway Company, to recover damages for alleged libel contained in a circular issued by them to the shareholders. The words complained of appeared in our last issue. The defendants admitted publication, said the words complained of were not libellous, and did not constitute a libel upon the plaintiff. They also pleaded that the words in their ordinary meaning were true in substance, and said they were privileged.

Sir E. Clarke, Q.C., and Mr. G. Spencer Bower appeared for the plaintiff; and Mr. Murphy, Q.C., Dr. Blake Odgers, and Mr. Hugh Fraser for the defendants.

Mr. Ebbsmith, who on the previous day gave evidence, was further examined by Mr. Bower. He was taken through a long correspondence referring to negotiations between the Electric Construction Corporation, local authorities, and the tramway company in regard to the adoption by the latter of an electric traction system.

While the plaintiff was being examined,

Mr. Murphy said that the jury would not be further troubled with the case. Having heard the statement of Sir E. Clarke, and having seen and heard Mr. Ebbsmith in the witness-box, the defendants desired him to say that, whilst they entirely reserved their rights to comment on the conduct of their own directors and of the plaintiff so long as he was their solicitor, they did not intend to convey that Mr. Ebbsmith's withdrawal from the Corporation or his change of name had anything to do with the determination of the connection with it of Jabez Balfour and Wright, and they expressed regret that the words used in the circular had led to that impression. They accepted the statement of the witness in the box that he had changed his name for family reasons, and that the Electrical Construction Company in no way resembled the other companies with which Mr. Balfour was so notoriously connected. They thought that the tramway company had entered into a contract which they ought not to have entered into, but there was no cause of complaint against plantiff in respect of that. He suggested that a *stet processus* should be entered.

Sir E. Clarke said he was not surprised that his learned friend had felt inclined to take the course he had, which was one entirely satisfactory to Mr. Ebbsmith. If the case had gone on he should have shown that the Electric Construction Corporation was an independent company, and was a strong and sound one. As the defendants had authorised his learned friend to make the statements he had done, Mr. Ebbsmith gladly made an end of the whole case, and was entirely satisfied with the course which had been taken.

The **Lord Chief Justice** said he had no doubt the parties had been wise, and a *stet processus* was entered.

COMPANIES' MEETINGS.

METROPOLITAN ELECTRIC SUPPLY COMPANY, LIMITED.

The seventh ordinary general meeting was held on Monday at Winchester House, Sir John Pender presiding.

The **Chairman**, in moving the adoption of the report and accounts (which were given in our last issue), said that they would have seen from the capital account that the second £50,000 of the debentures authorised in 1892 had all been issued, making a total of £100,000, nearly the whole of which was held by the shareholders. This issue of debentures brought the capital up to £600,000, which had practically been all expended, while the continual increase of new customers and the extension of mains would render it necessary for them to make still further provision for coming capital outlay. Referring to the other side of the capital account, they would find that the expenditure during the year had amounted to £35,072, the greater part of which had gone in mains and in the necessary apparatus and connections for supplying new customers. There had also been some expenditure at the Manchester-square and Sardinia-street stations. In the first of these cases, they had found it necessary to alter and supplement the foundations of the engines and machinery, in order to do away with any possible cause of complaint as to vibration, and these works were also having the effect of materially improving the working of the plant. They had doubtless seen that an action in reference to this question of vibration was in course of being heard. He assured them that the Board were fully alive to its importance, and had left no stone unturned to provide for the interests of the Company being properly and adequately guarded. With regard to the expenditure at Sardinia-street, they had sunk a well at the station, and had put down a pumping engine for the supply of water, and from the experience gained they had no doubt that they would be practically independent of the water company and water rates, and that a very considerable economy would thus be effected in one of their prime necessities. The item of management charges disappeared for the first time from the capital expenditure of the year. In dealing with this matter the Board had considered it right to allocate a small portion—about £700—of the salaries of the engineers' department direct to the more important items of construction, by way of percentage, as representing the work done by that department in the way of supervision and actual expenses. But no apportionment of general management expenses had been made to capital this year, the time having now arrived when, in the opinion of the Board, the whole of such charges should be born by revenue. This led him to the consideration of the revenue account itself, which in one sense had been somewhat disappointing. When in November last they issued a circular referring to the prospects of the Company, the Board were guided by the fact that in each of the three quarters which had then been completed the income from current had shown an increase of nearly 50 per cent. over the corresponding periods of 1892. They had therefore reason to hope that the Christmas quarter, under normal conditions of weather and demand for light, would show a similar increase. Owing, however, to the remarkable absence of fogs, and to the exceptional brightness of the general weather, the increase of revenue over the Christmas quarter of 1892 was only 8 per cent. And this was in spite of the fact that their customers were increasing in numbers in about the same proportion as usual. But all lighting companies had been seriously affected by the past winter, and it was simply repeating what had already been dwelt upon by the chairmen of other kindred companies. In their case they estimated the falling off at about £10,000, which, after allowing for extra cost of production, would have given an extra 1½ per cent. dividend on the capital. The total income from current had been £64,312, being an increase of £13,500 over 1892, which had been earned at an additional works cost of £6,600, which would have been only slightly increased to earn the larger income to which he had just referred. With regard to the item of fuel, the Board took full advantage of the reduced price of coal at the time the contracts were made last year, but the small increase of cost under this head as compared with earnings was not so much due to economy in purchasing as to the fact which the Board had always desired to impress upon shareholders—that increase of output did not involve anything like a proportionate increase of cost. The items remaining for special notice were the general management expenses, which now appeared for the first time as a full charge against revenue, and the depreciation fund. With regard to management, very considerable economies had been in operation since last year, reducing the total by nearly £4,000 from the cost in 1892; and as to depreciation, the Board were of opinion at present that the amount they had advised should be written off—namely, £7,000—with the further £1,000 off preliminary expenses—fairly met the case. The final result, as shown in the net revenue account No. 5, was a net balance (after providing for debenture interest) of £13,548. 19s. 4d. With this they recommend payment of a dividend of 5s. a share, carrying forward £1,073 to next year. They would have liked to recommend a larger dividend, but, under all circumstances, they considered that the progress was very encouraging, and that their business was being established on a firm and satisfactory basis. Their lamp connection was still continuing to increase in very much the same proportion as heretofore. The Board were of opinion that the time had now arrived for the institution of transformer sub-stations in some of the more crowded districts. By the adoption of this system they hoped to effect a considerable saving in the cost of supply. Before saying more he referred to a letter received that morning from one of the shareholders. He said he felt greatly disappointed that in the speech made last year the chairman referred to a dividend of 5 per cent. They would recollect also that that was not in the speech in moving the adoption of the report, but he did say, in answer to a question, that his belief was strong that, looking to the growth of the system, they would in all probability pay a 5 per cent. dividend, and he had shown them that day that but for the fact that one quarter's revenue had fallen off by £10,000, the dividend of 5 per cent. would have been declared. He was pleased to say, however, that in the March quarter of the current year their gross revenue amounted to £24,000; in 1893, for the same period, it amounted to £19,000; for 1892 it amounted to £13,000, while in 1891 it amounted to £10,000. They would therefore see that he was justified in saying that he looked forward with the greatest confidence to a 5 per cent. dividend at the end of this year. There were other prospects connected with the system which they might look forward to, and these were in the direction of the use of electric power. They had got these large buildings erected, and the mains laid down to serve customers, and there was no doubt that some means would be found for employing the enormous waste which existed at the present moment. They had

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not the power which the gas companies had of storing their electricity in great reservoirs, but if, with scientific progress and development, they could establish some cheap system of supplying electric power in large quantities, it would add enormously to the dividend-paying power of this and kindred companies At the time the Company was formed they thought they would receive at least £1 a light. The average price of the light to day was 8s. 9d. That was one of the difficulties they had had to contend against. Then, again, he thought the time would come soon when the different electric companies would have to meet and consider the question of approaching the Board of Trade with a view of inducing them to alter the restrictions and obstructions imposed upon electric lighting companies, which did not give them fair play. In conclusion, the Chairman moved the adoption of the report and accounts, and the declaration of the dividend recommended.

Lord John Hay, G.C.B., seconded the resolution, which, after some discussion, was carried.

The retiring directors, Lord John Hay, Mr. J. C. Parkinson, and Mr. J. D. Pender, were re-elected, and the auditors, Messrs. Deloitte, Dever, Griffiths, and Co., were reappointed. The proceedings terminated with a vote of thanks to the Chairman and directors.

BUSINESS NOTES.

Western and Brazilian Telegraph Company.—The receipts for the week ended April 20 were £2,940.

Worthing.—Dr. C. Kelly reports that the health of the district of Worthing is in a most satisfactory condition.

Liverpool Overhead Railway.—The traffic receipts of this railway for the week ending 22nd inst. amounted to £682.

Kingswood.—The Local Board have signed a cheque for £325. 10s. in settlement of electric lighting up to March 25.

Robey and Co., Limited.—Mr. W. W. Richardson, of Messrs. Doughty, Son, and Richardson, Lincoln, has joined the Board of this Company.

Appointment Open.—As will be seen by our advertisement columns, the Corporation of Sunderland require the services of an electrical engineer.

Ayr.—Mr. R. Hammond has made a survey of the burgh with a view to the introduction of the electric light. Mr. Hammond will submit a report to the Town Council.

Acton.—At a meeting of the Local Board it was announced that Mr. Medhurst was to have completed the agreement for the electric lighting of the district this week.

Church-Lighting.—It has been resolved to spend £2,000 in renovating and improving Marylebone Presbyterian Church. The electric light will be placed in the church.

Blackpool.—For the electric lighting of the Blackpool Tower Messrs. Crossley have laid down five gas-engines. Two are of 160 h.p., one of 60 h.p., and two of 35 h.p.

Sale of Business.—The business of Latimer Clark, Muirhead, and Co. is for sale by private treaty. Particulars may be obtained of Mr. J. Worley, 27, Leadenhall-street, E.C.

Newcastle.—A new block, Eldon-buildings, has now been erected at the north-east corner of Grey-street, Newcastle. The building is lighted by the electric light throughout.

Liverpool.—The business premises of Messrs. Henochsberg and Ellis, tailors and outfitters, Islington, are lighted by electricity. On the top of the cupola there is fixed a powerful electric search-light.

Wrexham.—The Town Council have accepted the offer of the Wrexham Electric Lighting Company to sell their provisional order for the installation of electric lighting in Wrexham and district for £350.

Glasgow.—At a meeting of the City Improvements Trust, Mr. W. F. Anderson moved for a return of lines and rentals between the Corporation and the Telephone Company, Limited. The motion was adopted.

Folkestone.—A public meeting has been held at the Tontine-street Cave, at which a resolution has been passed calling on the Corporation to abandon their electric lighting scheme. The proceedings were not unanimous.

The Leeds Tramways.—It may be well to remind our readers that the time for sending in tenders to the Corporation of Leeds for the working of the tramways throughout the city by horse, steam, cable, electric, or other power expires on May 5.

Canterbury.—The Canterbury Museum, Free Library, and School of Art Committee have accepted the tender of Mr. Philpott relative to the fixing of electric bells at the front door and the gallery. He will fix them and keep them in repair for two years for 30s.

Sunderland.—The Sunderland Shipbuilding Company, Limited, Sunderland, have built a new cargo steamer, 345ft. long, and of 5,400 tons dead-weight, to the order of Messrs. Adam and Co., of Aberdeen, Newcastle, and London. It is intended to fit her with electric light throughout, with cluster lights in the holds for discharging at night.

Bournemouth.—The Town Council have approved of the following plans of the electric supply company: transformer pit in Holdenhurst-road, mains for sub-station in Triangle to corner of St. Michael's-road, and transformer pit in Old Christchurch-road at entrance to Dragon Fly-lane. A plan for a new main from Queen's-road to Branksome Wood-road has been disapproved of.

London Agency.—Messrs. Mavor and Coulson, of Glasgow, inform us that they have appointed Mr. H. T. Barnett, of the London Electrical Goods Agency, St. Margaret's Offices, 53, Victoria-street, London, S.W., as their agent for the London district.

Sale of Plant.—Messrs. Welsby and Rousfield, of 51, Corn-street, Bristol, will sell by auction on May 10 the materials of the industrial section of the late industrial and fine arts exhibition, St. Augustine's Bridge, Bristol. Among these are switchboards and electric wires.

City and South London Railway.—The receipts of the Company for the week ended April 22 were £886, against £851 for the same period last year, or an increase of £35. The total receipts for the first half-year of 1894 show an increase of £44 compared with those for the corresponding period of 1893.

Tenders for St. Pancras.—As notified in our last issue, the Vestry of St. Pancras invite tenders for the buildings to contain the electric lighting plant (engines, dynamos, boilers, etc.) to be carried out at the electric lighting and refuse destructor station, King's-road, Camden Town, N.W. Tenders are to be sent in by the 7th May.

Bath.—At a meeting of the Surveying Committee, on the presentation of a bill amounting to £543. 7s. 6d. for electric lighting, it was reported that there had been 139 failures; in 71 cases they were of an hour's duration or more. A fine of 5s. in respect of 71 cases came to £17. 15s., and that sum deducted from £543. 7s. 6d. left £525. 12s. 6d. for payment. The bill was passed for payment.

Thomas Parker, Limited.—As stated in our note columns last week, this Company has been registered with a capital of £75,000, in £10 shares, the objects being to carry on business as electrical and mechanical engineers, and to generate and supply electric power and light. The signatories are John H. Woodward, Edmund S. G. Rees, Wm. Armistead, Chas. H. Iles, Lawley T. Smith, Mein Wilkie, and Robert Willcock.

Littlehampton.—At a meeting of the Local Board the clerk was instructed to reply to those gentlemen who had written to the Board on the matter of the electric light for the town to the effect that, although the Board do not contemplate supplying the electric light in their district at the present time, they would not oppose the formation of a company for the purpose, subject to the conditions being satisfactory to the Board.

York.—The Lord Mayor of York (Alderman Clayton) and the Electric Light Committee of York have visited Oxford for the purpose of inspecting the system of electric lighting adopted by the Oxford Electric Light Company, Limited. The central station at 45, Broad-street and the sub-distributing station in St. Giles's were visited. The committee also visited the works of the Electric Construction Company, Limited, Wolverhampton.

Great Northern Telegraph Company.—The report of the Great Northern Telegraph Company of Copenhagen states that the total receipts for the year 1893, including the balance brought forward, amounted to £352,974, and the expenses to £77,792, leaving a net profit of £275,182. After placing £83,333 to reserve and renewal fund, the directors recommend a final dividend amounting to £54,166, leaving a balance to be carried forward of £38,154.

A Reflecting Standard.—Messrs. Faraday and Son have brought out a reflecting standard for pictures, etc. The standard, which when extended is 5ft. high, is very light and portable. The reflector is a powerful mirror of six sides, thus overcoming the projected image of the lamp filament. The adjustment, in either vertical or lateral directions, is readily made. The standard is light and portable. The tripod and stem are made of black wrought iron.

Brazilian Submarine Telegraph Company.—The report of the directors for the half-year ended December 31, states that the revenue amounted to £96,261, and the expenses to £24,284. After providing for debenture interest, sinking funds, and income tax, there remains a balance, including £3,533 brought forward, of £61,207. First and second interim dividends, amounting to £39,000, have been paid, and £20,000 transferred to reserve, leaving £2,207 to be carried forward.

Stock Exchange Quotations.—Applications have been made to the Stock Exchange Committee to appoint a special settling day in, and to grant a quotation to the £15C,000 5 per cent. debentures of the Telegraph Construction and Maintenance Company, Limited, in lieu of £150,000 5 per cent. bonds expired January 1, 1894. The committee have ordered the partly paid scrip of £100,000 5 per cent. debenture stock of the City of London Electric Lighting Company to be quoted in the official list.

Progress of Lighting in the City.—We are informed that the revenue of the City of London Electric Lighting Company from public service during the first three months of the year was £3 100, and from private £12,460, a total of £15 560, as against £7,839 in 1893, being an increase of £7,721. The number of 8-c.p. lamps connected on March 31 was 84,634, being an increase during the quarter of 19,293, against 35,275, and an increase of 15,034 at the corresponding period 12 months ago.

Electricity v. Gas.—At the eleventh annual meeting of the Gas Managers of Scotland, Mr. Thomas Wilson, of the Coatbridge Gasworks, expressed the opinion that gasmakers were threatened with opposition from electricity on all sides, and that it was a splendid light, but an expensive one. Gas companies, he thought, had nothing to fear from this source. With the improvements effected, and the appliances at the works, together with the increased uses of gas, it was certain to hold its own.

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Messrs. Drake and Gorham.—Although this is generally considered a slack time of the year in the trade, at least one firm—Messrs. Drake and Gorham—have a large amount of work in hand, both in the way of country house and town lighting. Baron William von Schröder has placed the lighting of the Rookery in their hands. There will be a steam-engine driving a latest pattern Construction dynamo, to provide current for charging a 100-light D.P. battery. The total number of lamps being installed is 200.

Direct Spanish Telegraph Company.—The directors have passed a resolution with regard to dealing with the £62,000 6 per cent. debenture debt which falls due on May 1 next, which provides for calling up the balance of £1 unpaid on the ordinary shares (£12,931), the issue of debentures for £30,000 having 20 years to run and bearing interest at 4½ per cent. per annum, and realising and taking from the reserve fund the requisite balance, approximately £19,000, and paying off by these means the debentures falling due.

Valencia and Alberique Tramways Company, Limited.—This Company has been registered with a capital of £100,000 in £1 shares. The object is to purchase or otherwise acquire from J. Latorre a concession granted by the Government of the kingdom of Spain for the construction of a system of tramways between the towns of Valencia and Alberique, and to carry on business as omnibus proprietors, carriers, electrical engineers, etc , in Spain and elsewhere. The first signatories are S. de los Valles, T. G. Harvey, J. H. Brodie, A. G. Hammond, A. Hulbert, A. J. Secretan, and A. D. MacLaren.

Underground Mains.—The underground work for the Edinburgh Corporation electric light scheme is now in progress. The Doulton casing, as stated in our last issue, is being used, and about 50 miles of "ways" on this system will be laid. The Sunderland conduits will, we understand, shortly be commenced, and for this work about 10 miles of "ways" of Doulton casing will be provided for the reception of the cables. Some bare copper mains in culverts will be laid both at Edinburgh and Sunderland, and special insulators for the work are being supplied by Messrs. Doulton and Co., of Lambeth.

Hooper's Telegraph and India Rubber Works.—We are informed that the estate of the late Mr. William Hooper has now been taken out of Chancery, and that the telegraph and indiarubber works will in future be carried on by Messrs. Jno. P. Hooper and Basil Gee as managing directors of Hooper's Telegraph and India Rubber Works, Limited, 31, Lombard-street, London, E.C., which has been formed for the purpose of continuing the business of manufacturers of indiarubber telegraph cable and general indiarubber goods, and extending the same for the supply of electric light, telephone, and other cables.

Portsmouth —At the electric lighting station, Gunwharf-road, Portsmouth, last week, Mr. Alderman G. Ellis, chairman of the Electric Lighting Committee of the Town Council, turned on the steam from the boilers which are to work the engines for driving the dynamos. A pressure of 165lb to the square inch was obtained. The Hopkinson low-water alarm was tested at the same time, under the superintendence of the Manchester Steam Users' Association, who are acting for the insurance company. The first light was switched on in the engine room. The Mayoress will shortly switch on the electric light for the borough.

Llandudno.—At a meeting of the Improvement Commissioners, the Board sitting in committee read a letter from Messrs. Bellis and Kingsland forwarding, in accordance with the resolution passed by the Board, a draft of the provisional order which they propose *re* the electric lighting of Llandudno. To meet the wishes of several members of the Board, they had omitted the terms of their first suggestion as to purchase, and in lieu thereof inserted a like purchase clause to that in the Bournemouth order. They also included in the draft order the whole of the Commissioners' district. It was resolved that the proposed order and terms be referred to a committee for consideration and report.

Shirley.—At the last meeting of the Shirley and Freemantle Local Board of Health, it appeared from the minutes that an extraordinary meeting of the Board had been held, at which it was resolved that the clerk (Mr. Harle) should apply to the Board of Trade for a license to enable them to supply the district with electric light, and that the clerk take all the necessary steps to carry out the decision of the meeting. The Clerk explained that he had received a long letter from the Board of Trade, in which they stated that it was advisable that the Board should apply for a provisional order. The matter was referred to committee. Subsequently the Clerk announced that he had received several letters from the Brush Electric Lighting Company.

Royal Agricultural Hall —The Theatres and Music Halls Committee of the London County Council report that Messrs. Crompton and Co., Limited, have made an application to the Council for approval of a system of arc lighting for the Royal Agricultural Hall. The suspension of the lamps is effected by means of the conductors, but these are of ample strength, and the engineer of the Council is of opinion that as arranged there is no risk of short-circuit in this portion of the system. They recommend that the application be granted. Messrs. Gent and Co , of Leicester, have secured the contract for lighting the offices and shops into which the centre of the hall has been divided (over 100 in number), and also the stands and exhibits at the forthcoming shoe and leather fair.

Tenders for Exminster.—As stated in our last issue, the Committee of Visitors of the Devon County Asylum, Exminster, invite samples and prices of the following materials: (1) per mile, tinned and stranded copper wires from $^{3}/_{22}$ S.W.G. to $^{19}/_{14}$ S.W.G., insulated with pure and vulcanised rubbers, the insulation resistance of which shall not be less than 600 megohms per mile; (2) per pound, pure rubber strip vulcanising rubbers, prepared tapes, and indiarubber solution; (3) per 1,000ft., best American whitewood casings and moulded covers, in various sizes, from 1½in. to 4in. in width; (4) per gross, single-light cut-outs, ceiling plates, with wooden cord grips, quick-action make-and-break switches, holders and shade carriers, brackets and shades. Tenders should be sent to Mr. Arthur E. Ward, 9, Bedford-circus, Exeter, clerk to the committee, by May 15.

Worcester.—The Town Council have adopted a report of the Water Committee recommending the acceptance of the tender of the Brush Company to supply and fix two sets of electrical pumping plant, consisting of two motors of 30 b h.p., and two three-throw pumps capable of delivering 10,000 gallons per hour to an elevation of 300ft. through 5,000 yards of 10in. main, at an estimated cost of £1,128; and also to lay a main capable of conveying a current sufficient to drive the motors and light 1,000 lamps *en route* from Castle-street to the waterworks at an estimated outlay of £961. During the past year the Town Council borrowed sums amounting to £24,240 for water supply, electric lighting, and street improvements. During the current year the Council expect to borrow other sums for street improvements, water supply, electric lighting, and sewerage works.

Stafford.—At a meeting of the Stafford Town Council, on the report of the Electric Lighting Committee a long discussion has taken place on a recommendation that the tender of Mr. Lovatt, of Wolverhampton, be accepted for the erection of the buildings for the electric lighting plant. At one committee meeting the tender of Mr. Espley, Stafford, was accepted, though it was £20 more than that of Mr. Lovatt, but at a later meeting that decision was changed and the tender of Mr. Lovatt accepted. An amendment was moved that Mr. Espley's tender should be accepted. The arguments advanced in favour of the amendment were that Mr. Espley was a local man, a large ratepayer in the borough, and a large employer of local labour, and it was contended that that was a sufficient reason for accepting his tender, though it was £20 more than that of Mr. Lovatt's. On the other hand, it was affirmed that it was in the ratepayers' interests to accept the lowest tender. In the end the amendment was defeated by 17 to 13 votes.

Birmingham.—The General Purposes Committee of the City Council report as follows with reference to the Birmingham Electric Light and Power Order, 1894: "With reference to Council minutes referring this order to your committee, they report that the areas over which the company propose to extend their powers are practically the same as those embodied in their application of 1892, and referred to in your committee's reports of December 6, 1892, and July 25, 1893 Area No. 1 commences at the junction of Easy-row and Edmund-street, and proceeds thence along Easy-row, Great Charles-street, Summer-row, Parade, Newhall-hill, Legge-lane, Albion-street, Tenby-street, Tenby-street North, Warstone-lane, Vyse-street, Hylton-street, Great Hampton-street, Constitution-hill, Snow-hill, Steelhouse-lane, Stafford-street, Dale-end, Newton-street, Corporation-street, Old-square, Minories, Bull-street, Colmore-row, Livery-street, and Edmund-street to its junction with Easy-row. Area No. 2 commences at the junction of Easy-row and Broad-street, proceeding along Easy-row, Paradise-street, Pinfold-street, Stephenson-street, Stephenson-place, New-street, Worcester-street, Bell-street, Spiceal-street, Edgbaston-street, Smallbrook-street, Holloway-head, Bath-row, Islington-row, Wheeley's-road, St. James's-road, Charlotte-road, Wellington-road, Bristol-road, Priory-road, Park-road, Somerset-road, Richmond-hill, Brook-road, Westfield-road, Woodbourne-road, along the Harborne Railway to Hagley-road, Hagley-road, Manor-road, Melville-road, Lyttleton-road, Park-road, York-road, Portland-road, Hagley-road, Monument-road, Lady-wood-road and Broad-street to its junction with Easy-row. The draft order, as submitted by the promoters, did not appear to your committee to give sufficient advantage to the public in return for the important concessions sought by the company. They therefore instructed the town clerk to lodge a notice of objection on behalf of the Corporation with the Board of Trade. A copy of this notice having at the same time been sent to the promoters, negotiations took place between them and your committee, with the following result: (1) The authorised maximum price for electric energy to be reduced from 10d. to 8d. per Board of Trade unit, the minimum charge per quarter being reduced from £3. 10s to £3. 6s. 8d.; this to apply to energy supplied under the existing orders of 1889 and 1891, as well as to that to be supplied under the new order. (2) The promoters to be compelled to lay mains in certain streets in each area agreed to by your committee within two years from the confirmation of the order. (3) The clauses of the Board of Trade model order with respect to street boxes, supply of energy to owners and occupiers, and to public lamps, etc., to be inserted. The promoters have agreed to these conditions, and as time was pressing, your committee, in pursuance of the authority given them by the Council, have, subject to the insertion of clauses in the order for carrying out the foregoing arrangements, given the necessary consent to the application."

Barnet.—At a meeting of the Barnet Local Board, a lengthy report by the Electric Lighting Committee was read. The committee stated that they had received a letter from the Brush Electrical Engineering Company giving terms on which they would light the district. A draft agreement was also submitted to be signed by householders agreeing to take for a period of at least three years from the commencement of such supply, an amount of energy not less than 30 units per lamp fixed per annum, and pay

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for the same at the rate of 6d. per unit. A report had also been received from Messrs. Crompton and Co., Limited, upon the same question, and the committee was advised by the company that the supply of electric light could be successfully undertaken if from 2,000 to 3 000 8-c.p. lamps were fixed in private houses. The price to be 6d. per unit, a price which the Brush Company say "is unquestionably cheaper than the present price (in Barnet) for gas, to say nothing of deterioration of decorations, pictures, books, and tradesmen's stocks." On the other hand, the committee are advised that the installation of the necessary wires and fittings inside a house, the expense of which would have to be met by the owner or occupier, will cost at least 25s. for every point to which the current is taken. The committee remind the ratepayers that electricity is now suitable for cooking and warming as well as for lighting purposes. At an adjourned committee, a draft circular was prepared with the object of asking householders as to whether they were prepared to take the light, and the committee recommended that 500 circulars and 500 agreements be printed and left by the collector at the houses of ratepayers whose assessments exceed £20, and if not returned by May 12 be called for. Attention was called to the fact that if the undertaking is to pay its working expenses, there must be an annual income from private lighting amounting to about £1,100 or £1,200 per annum, after taking credit for £465 as now paid for public lighting. To get this income it is necessary that the undertaking should have 2,000 lamps fixed in private consumers' houses, taking on an average 25 units of electricity per lamp per annum, and paying at 6d. per unit 12s. 6d. per lamp fixed per annum to the undertakers. In conclusion, the committee, after taking all the circumstances into consideration, felt it would not be prudent for them to proceed further until the Board was assured in a manner admitting of no mistake that if the Board undertook the electric light under their provisional order (at an expenditure not far short of £10,000) the necessary income will be forthcoming from private consumers to pay the working expenses of the undertaking as well as interest on capital and sinking fund. The committee also pointed out that on the assumption that the estimates are accurate and the private consumers take the light to the extent mentioned, the income would be sufficient to pay working expenses together with interest at 4½ per cent. to include sinking fund. The committee also recommended that a cheque be drawn for £10 in favour of the Brush Electrical Engineering Company. The report has been adopted, and the circulars and agreements are to be printed and circulated.

PROVISIONAL PATENTS, 1894.

APRIL 16.

7530. **An improvement in electrical glow lamps.** The Edison and Swan United Electric Light Company, Limited, and John Miles Moffat, 28, Southampton-buildings, Chancery-lane, London.

7539. **Improvements in lifting, crane, and hoisting apparatus operated by electrical energy.** George Llewellyn Davies, 55, Chancery-lane, London.

APRIL 17.

7603. **Application of electricity to the manufacture of cyanides and ferrocyanides and improvement in same. Preservation of vessels from corrosion.** Charles James Hammerton, 8, St. John's-terrace, Rosebery-avenue, Clerkenwell, London.

7607. **Improvements in arc lamps.** Wolf Defries and Victor Isidore Feeny, 60, Queen Victoria-street, London.

7617. **Improvements in thermo-electric generators.** Harry Barringer Cox, 46, Lincoln's-inn-fields, London. (Complete specification.)

7645. **Improvements in underground conduits for electric railways.** James Buchanan Brand and Claud Lorraine Franklyn, 37, Chancery-lane, London. (Complete specification.)

APRIL 18.

7684. **Improvements in or in connection with electricity meters.** Wilfrid L. Spence, The Elms, Seymour-grove, Manchester.

7688. **Improvements in or in connection with electricity meters.** George Hookham and Sydney Holmwood Holden, 18, Southampton-buildings, Chancery-lane, London.

7691. **Improvements in the manufacture of carbon rods for electric arc lights.** Charles August Müller, 2, Market-street, Bradford. (Christian Schmelzer, Germany.)

7700. **Improvements in electric light ceiling roses.** Joseph Devonport Finney Andrews, 15, Marsham-street, Westminster.

7711. **An improved arrangement of element board for electro-diagnosis.** William James Bishop, 70, Chancery-lane, London.

7718. **Improvements relating to mains for alternate-current installations.** George Gatton Melhuish Hardingham, 191, Fleet-street, London. (The firm of Felten and Guilleaume, Germany.)

APRIL 19.

7758. **Improvements in induction electrical machines.** Frederick Tudsbury, 15, St. James's-row, Sheffield.

7801. **Improvements in or relating to electrolytical apparatus.** Carl Kellner, 46, Lincoln's-inn-fields, London.

APRIL 20.

7815. **Improved means for effecting the lighting of velocipedes by electricity.** Thomas James Tomlinson, jun., and Oswald Robson, 3, St. Nicholas-buildings, Newcastle-on-Tyne.

7853. **An improvement in the electro-deposition of heavy metals with a base metal alloy.** William Arthur Thoms and William Henry Burgum, 58, Lombard-street, London.

7865. **Improvements in the construction and working of galvanic batteries.** Desmond Gerald Fitz-Gerald and Alfred William Southey, 53, Chancery-lane, London.

7879. **Improvements in and relating to reflectors for electric arc lamps.** Carl Coerper, 45, Southampton-buildings, Chancery-lane, London. (Complete specification.)

APRIL 21.

7905. **An improved shunt arc lamp.** Robert James Canavan, 27, Tavistock-place, London.

7920. **Improvements in lead-sheath cables.** James Bassnett Atherton, 6, Lord-street, Liverpool.

7933. **Portable apparatus for heating by electricity water, milk, or other liquids contained in cups, jugs, or other vessels, and for making tea and other drinks.** William Corin, 77, Chancery-lane, London.

7935. **Improvements in electric telegraphy.** Kay Oskar Arthur Gulstad, 46, Lincoln's-inn-fields, London.

7950. **Improvements in apparatus for electrolytical purposes.** Herbert Guthrie, 46, Lincoln's-inn-fields, London.

7955. **Improvements relating to electric measuring instruments.** Jocelyn Home Thomson, 124, Chancery-lane, London.

SPECIFICATIONS PUBLISHED.

1893.

6528. **Dynamo-electric machines, etc.** Statter.

6551. **Electrically treating gaseous bodies, etc.** Hall.

8567. **Electric lamps.** March.

10081. **Electromotors.** Greenhalgh.

11973. **Electrolysis of water.** Siemens Bros. and Co., Limited, and Obach.

14469. **Electric arc lamps.** Richardson

1894.

3045. **Electric insulating compound.** Bäärnhielm and Jernander.

3902. **Applying electromotors to lathe work.** Chamberlain and Hookham.

COMPANIES' STOCK AND SHARE LIST.

Name.	Paid.	Price Wednesday.
Birmingham Electric Supply Company	5	5⅛-5⅜
Bournemouth Electric Company	—	—
Brighton and Hove Company	100	210-215
Brush Company, Ordinary	3	2¼-3
—— Nom. Cum., 6 per cent. Pref.	2	2¼-2⅝
—— 4½ Debenture Stock	100	108-111
Charing Cross and Strand	5	4-5
Chatham and Rochester	—	—
Chelsea Electricity Company	—	—
City of London, Ordinary	10	12-13
—— 6 per cent. Cumulative Pref.	10	13¼-13⅜
City and South London Railway, Consolidated Ordinary	100	27-32
—— Debenture Stock	100	108-110
—— 5 per cent. Pref. Shares	10	10⅜-11¼
Crompton and Co., 7 per cent. Cum. Pref. Shares	5	3¾-4
—— 5 per cent. First Mortgage Debentures—1-400 of £100 and A, 1-200 of £50	—	95-100
Elmore's French Company	3	⅛-¼
Electric Construction, Limited	2	¾-1
—— 7 per cent. Cumulative Pref.	2	1½-1⅝
Elmore's Copper Depositing	2	⅛-¼
Electricity Supply Company for Spain	5	—
Elmore's Wire Company	2	⅛-¼
Fowler-Waring Cables	5	¾-1¼
House-to-House Company	5	¼-1
India Rubber and Gutta Percha Works	10	23-24
—— 4½ per cent. Debentures	100	101-103
International Okonite, Ordinary	10	1-2
Kensington and Knightsbridge	5	4¾-5¼
Liverpool Electric Supply, Ordinary	5	6⅜
—— Pref.	4½	5¾-6⅛
London Electric	5	⅜-1⅛
Metropolitan Electric Supply	10	7¼-7⅞
—— 5 per cent. Reg. Debentures, 1-10,000 in Bonds of £10, £20, and £40	—	106-109
National Telephone, Ordinary	5	4⅜-4⅞
—— 6 per cent. Cum. First Pref.	10	15-16
—— 6 per cent. Cum. Second Pref.	10	14⅜-15⅛
—— 5 per cent. Nom. Cum. Third Pref.	5	5⅛ 5⅝
—— 4½ per cent. Deb. Stock	—	116-118
Notting Hill Company	10	4¾-5¼
Oriental and Electric Company, £1 shares	11	⅜-½
Southampton Electric Company	—	—
St. James's and Pall Mall, Ordinary	5	6⅜-7¼
—— 7 per cent. Pref.	5	8-8⅜
Swan United	3½	2-2⅛
Telegraph Construction and Maintenance	12	39-41
—— 5 per cent. Bonds	100	—
Westminster Electric Supply, Ordinary	5	5⅛-6⅛
Yorkshire House-to-House	4½	4¼-4⅞

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NOTES.

Portsmouth.—The central station is to be set in operation on the 9th inst.

Aunay-sur-Odon.—M. Fauvel has lighted part of this country town electrically.

Thuringia.—Telephonic communication is to be established between Jena and Weimar.

Zipf.—An electric railway is to be constructed between Zipf and the railway station at Redl-Zipf.

Creil.—The Northern Railway Company are about to electrically light the Creil railway station.

Vals-les-Bains.—Work in connection with the electric lighting of the town is progressing actively.

Budapest.—Large extensions of the electric light conductors are being made in the streets here.

Saint-Girons.—Both public and private electric lighting is on the point of being commenced.

Telephony in France.—It is proposed to establish a third telephonic circuit between Paris and Havre.

An Imperial Train.—A new train just completed for the use of the Czar is lighted throughout by electricity.

Electro-Therapeutics.—A service of electro-therapeutics is to be established in Paris at the Saint-Louis Hospital.

Nischni-Novgorod.—The municipal authorities of this Russian commercial town have decided to build three electric tramway lines.

Marseilles.—The local gas company, which also supplies the electric light, is making extensions in the public electric lighting.

Society of Arts.—On Wednesday evening next Colonel Wells will read a paper on "Telegraphs and Trade Routes in Persia."

Basse-Loire.—The Bridges and Roads Department are considering the question of electrically lighting the banks of the Basse-Loire Canal.

Sainte-Ursanne.—At some new works to be established by M. Rollier electromotors will be used, the motive power being obtained from the River Doubs.

Exhibition at Luxembourg.—An exhibition of work is to be held here this year. Electrical machinery and apparatus are to take a prominent position.

Aix-la-Chapelle.—The horse tramway between Aix-la-Chapelle is to be converted into an electrical line. The financial arrangements have been completed.

Schwanenstadt. — Messrs. Siemens and Halske, Messrs. Ganz and Co., and the Oerlikon Works have sent in offers for the electric lighting of this town.

Electric Shot Firing in Mines.—Mr. Atkinson, the Government inspector of mines, believes in shot firing in mines being effected by electrical methods. And so do we.

Chateau d'Œx.—There is under consideration the question of the electric lighting of the town and neighbourhood, and of the installation of the telephone in the valley.

Metallic Circuits.—The National Telephone Company are introducing metallic circuits throughout the Metropolis. And this after the opposition before the Joint Committee on Electric Powers!

Saint-Quentin.—The local gas company is installing the electric light in part of the town. Power is obtained from gas-engines of 70 h.p. Underground cables on the three-wire system are employed.

Fire at Montreal.—A fire occurred on Tuesday in the Royal Electric Works. Twenty-five dynamos were destroyed, and when the conflagration was at its height the immense flywheel of the largest engine burst.

Saint-Clars (Gers).—The Municipal Council has appointed a commission to investigate a scheme, presented by M. A. Laforgue, of that district, for the establishment of an electric light and power station.

Newport Tramways.—We wonder whether the Corporation of Newport, who are advertising for tenders for the working of the local tramways, would consider the advisability of electric traction being introduced.

The Institution.—The next meeting of the Institution of Electrical Engineers will be held on Thursday, the 10th inst. The discussion will be resumed on the paper by Mr. Crompton on "The Cost of Electrical Energy."

Traction in Algiers.—A project has been submitted to the Municipality by M. Delaise, of the Algiers Omnibus Company, for the construction of an electric tramway on the trolley system. The scheme is under consideration.

Exhibition at Derby.—An electrical exhibition is to be opened in the Mechanics' Institute on the 14th inst. Sir Frederick Bramwell has consented to give a lecture in connection with the exhibition in the Guildhall on May 16.

Bill for Exempting Tenant's Machinery from Rating.—The second reading of this Bill stands for Wednesday next, 9th inst., and it is of the greatest importance that a large majority should be obtained in its favour.

Central London Railway.—The Unopposed Bill Committee of the House of Commons have passed the Bill of the Central London Railway, under which an extension of time is granted until 1900, within which to complete this undertaking.

Warasdin.—This town in Croatia is to be lighted by electricity shortly owing to the efforts of the Industrial Society. The neighbouring town of Czáktornya, which is on Hungarian territory, has been lighted electrically for some months past.

Bingen.—The local Chamber of Commerce has petitioned the postal authorities for the construction of a telephone network for all the large towns of the Rhenish district from the Neckar to the Dutch borders, and specially between Coblence and Bingen.

Chalon-sur-Saone.—The Municipality have reported favourably upon a scheme of Messrs. Péletin and Mollard for the construction of an electric tramway between Chalon-sur-Saône and Bourgnef. The line will be 7½ miles in length, and will cost £40,000.

The Institution Conversazione.—The annual conversazione of the Institution of Electrical Engineers will take place on Thursday, the 31st inst., and will be held, as on previous occasions, in the galleries of the Royal Institute of Painters in Water Colours.

Institution of Engineers and Shipbuilders.—The closing business meeting of the session of the North-East Coast Institution of Engineers and Shipbuilders will be held in the physical lecture-hall of the Durham College of Science, Newcastle, on Tuesday next, the 8th inst.

Auchel.—The Municipality of Auchel, Pas-du-Calais, have had before them a proposal from a contractor to undertake the gas lighting of the town. The question has been postponed, the Municipality expressing their preference for the introduction of the electric light if possible.

B.Sc. Degree in Engineering.—The Edinburgh University Court have decided to recognise the day

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lectures and laboratory courses given by Prof. Andrew Jamieson at the Glasgow and West of Scotland Technical College, as qualifying *pro tanto* for their degree of B.Sc. in engineering.

Long Winded.—The New York *Electrical Engineer*, in its issue of the 18th April, devotes the insignificant number of 26 pages to an illustrated description of the new head-quarters in which the Postal Telegraph Cable Company has now become established. The *Electrical World* disposes of the subject in 16 pages.

Accumulator Traction.—The management of the Grand Berlin Horse Tramway Company have erected an accumulator station at their premises in Waldenser and Wiclef streets, and will experimentally work a line on the accumulator system from Werftstrasse (Moabit) to Hansa-platz, Lützowplatz, and Potsdamerstrasse.

Protection of Users of Artificial Lights.—In the Metropolis many persons are grumbling about the high charges made for gas on the north of the Thames. In France there exists an organisation to promote the interests of users of gas, electricity, and petroleum, and the third congress of this federation will be held at Rheims in June next.

Lighting of Waterloo Bridge.—The London County Council have referred to the Highways Committee a petition from the ratepayers of North Lambeth calling attention to the Act of Parliament passed last session providing for the lighting of Waterloo Bridge by electricity, and praying that the Council will no longer delay carrying out the work.

Personal.—Mr. Reginald H. Drummond, A.M.I.E.E., has been appointed chief electrician in the Madrid station of the Electricity Supply Company for Spain, Limited. Mr. Drummond, who was formerly engaged as assistant electrical engineer at the Bankside station of the City of London Electric Lighting Company, has already commenced his duties in Madrid.

A Roundabout Method.—Our Berlin contemporary *Kuhlow's German Trade Review and Exporter* frequently gives information as to electrical matters in Germany. The joke of the matter is that *Kuhlow's* does not go to the fountain head for its information, but waits until we have abstracted items from the German technical Press and then scissors our abstracts.

Electric Lighting in Calcutta.—The *Indian Engineer* states that "Messrs. Octavius Steel and Co. have secured the contract for fitting up an electric lighting plant for the United Service Club, in competition with the India Rubber Gutta Percha Company, Limited, the Oriental Telephone Company, Limited, Messrs. Kilburn and Co., and Messrs. Siemens Bros. and Co."

Arsenical Telegraph Batteries.—According to a Leipzig paper, a number of Post Office officials at Abterode have fallen ill owing to the telegraph batteries containing arsenical zinc and arsenical vitriol. Prof. Dietrich, of Marburg, confirms this theory, but, on the other hand, there is the fact that the postal authorities always test the quality of the materials supplied to them.

Electric Gambling Devices.—Complaints are sometimes made in the United States that American progress in electricity is not fully acknowledged in other countries. No one, however, is likely to grudge them the honour (?) of introducing electricity into gambling devices, with the object of swindling greenhorns. But that, it appears, is what is now being done in America.

Electricity Running about an Area!—A lady complained to a magistrate a few days ago that an electric battery that someone had placed in the area of her house annoyed her. She was unable to see it, however, but she could hear it working, and the wires went everywhere. If the lady had been able to see it, there might have been another case of assault and battery.

Heilbronn.—The Wurtemburg Portland Cement Works at Lauffen-on-the-Neckar report that their electricity station, which has now been in operation for five years, is making good progress. A larger demand has enabled prices to be lowered. A new turbine has been installed. At the end of 1892 there were supplied 3,743 incandescent lamps, 32 arc lamps, and electromotors of 48·6 h.p.

German Incandescent Lamp Manufacturers.—A conference of incandescent lamp makers has been held in Berlin with the object of raising the price of lamps. It was decided to form a union of European incandescent lamp manufacturers, and to fix the minimum price per lamp at 75 pfennige (or, say, 9d.) to direct consumers and at 65 pfennige (or, say, about 8d.) to middlemen.

Messina.—Mr. Charles M. Cautry, the United States consul at Messina, in an official report states that the local supply of gas is of bad quality and dear in price. It appears to him that there is an opportunity for an electric light company, the people in Italy being willing to adopt the latest and best illuminant. He says the local tramway company, which has about 40 miles of line, would also be open to adopt electricity as a motive power.

The Lundy Island Cable.—The Lundy Island cable has proved so valuable to vessels frequenting the Bristol Channel, that a useful extension has been made whereby the island is now placed in communication with all parts of the mainland both by day and night. The Lundy cable is 18 to 20 miles in length, and forms a part of the coast telegraphic communication scheme for the purpose of summoning lifeboats and assistance to vessels in distress.

Vibration.—It will be seen from our legal columns that Mr. Justice Stirling has granted an injunction for vibration and enquiry as to damages in the action brought against the Metropolitan Electric Supply Company. The injunction has been suspended for three months, with the possibility of an extension of time being granted. In the meantime it is to be hoped that the precautions being taken by the company to overcome vibration will be successful.

Institution of Engineers and Shipbuilders in Scotland.—At the annual general meeting of this institution last week, the awards of medals and premiums for papers read during session 1892-93 were made. A premium of books was awarded to Mr. John Barr for his paper on "Testing Machinery and Electric Level Recording Apparatus." The discussion of the paper by Mr. William Arnot, A.M.I.C.E., on "The Glasgow Corporation Electric Light Supply," was continued and terminated.

Rubber in Madagascar.—A concession has been granted by the Prime Minister and Commander-in-Chief of Madagascar to the Hon. John L. Waller, ex-United States Consul there, measuring in area 15 miles square, in the district of Fort Dauphin, on the south-east coast, and which is conceded to be one of the richest rubber districts in the island. The discovery of rubber in the district is of recent date; the article is said to be of excellent quality, and is found in large quantities throughout the district.

Lighting of the Baltic Canal.—We referred to the work to be done in connection with the electric lighting of this canal in our last issue. Tenders have now been opened for the same. Nine companies sent in tenders. The Esslinger Maschinenfabrik made the lowest at 513,000

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marks, with an alternate tender of 490,000 marks, or say £25,650 and £24,500. The Schwartzkopff Company, of Berlin, tendered at 553,000 marks, the General Electricity Company at 640,000 marks, and Messrs. Siemens and Halske at 820,000 marks.

The Lyons Exhibition.—In our issue of the 13th ult. we mentioned that among the electric tramways to be shown at this exhibition would be one constructed by the Creusot Works from the designs of M. Lombard-Gerien, and another by the Fives-Lille Company, in which polyphase currents would be employed. Mr. J. Claret, the promoter of the exhibition, has now arranged to construct on the left bank of the Rhone, between the Lafayette Bridge and the Park, an electric tramway, the main features of which resemble the Lineff system.

Laying of New Mains.—The House-to-House Electric Light Company intend to lay mains in Earl's Court-road, between Wetherby-road and Earl's Court-square; the St. James and Pall Mall Company are about to lay a new feeder main from the station in Carnaby-street along Beak-street, Upper and Lower James streets, Golden-square, Brewer-street, Sherwood-street, and Denman-street, and across Shaftesbury-avenue to the distributing mains in the subway there; and the Charing Cross and Strand Electricity Supply Corporation intend to lay mains along Long-acre, Drury-lane, White Hart-street, Eagle place and court, and across Catherine-street and Marquis-court. The London County Council have approved of the carrying out of these works.

Electrical Apparatus for Amateurs.—Under the title of "Electrical Apparatus for Amateurs," Messrs. Ward, Lock, and Bowden, Limited, of Warwick House, Salisbury-square, E.C., have issued a book of 104 pages giving instructions how amateurs in electrical matters may make electrical apparatus for home use. The book, which is edited by Mr. Francis Chilton-Young, is divided into five parts, each of which has been written by a different person. The first—by Mr. G. H. Sayer—deals with "How I made my Telephones"; the second—by Mr. G. Edwinson—with "The Domestic Electric Light"; the third—also by Mr. Edwinson—with "Magneto-Electric Machines"; the fourth—by Mr. C. J. Clarke—with "A Cylindrical Electrical Machine"; and the fifth—by Mr. R. Williams—with "How I Built my First Coil."

Electric Tramway at Lyons.—A new electric tramway between Lyons and Oullins has been opened by the Lyons Omnibus and Tramway Company. At the generating station there are two Bonnet-Spazin boilers of 140 square metres heating surface supplying steam to two Piguet engines. Each of these is of 150 h.p., running at 100 revolutions per minute, and driving a four-pole Thomson-Houston dynamo. The current is transmitted to the motors by overhead conductors. There are at present in use eight cars, each capable of carrying 50 passengers. The old rolling-stock of the company has been employed, and each car is fitted with two Thomson-Houston motors, which in case of need suffice for conveying 100 passengers. The cars are lighted by five incandescent lamps, three inside and one at each end.

Fibre Conduits.—A new type of conduit for under ground cables has been brought out by the Fibre Conduit Company, of New York. The conduit is made of wood fibre treated with an insulating and preserving compound, producing a hard and solid substance. The fibre is made into tubes, which are completely saturated with a treating mixture which has been prepared under the direction of chemists. The finished pipe is in 5ft. lengths, and is uniform in thickness, with smooth surfaces. It is claimed that this tube makes a strong and perfectly tight duct, which can be readily opened at any point to tap the cables; that it can be easily put together; and that when laid underground it is much more durable than iron, being unaffected by either acids or alkalis. It is also claimed not to contract or expand, or to be injured by heat or cold.

Electric Motors in Workshops.—M. L. Baumgardt describes in a recent issue of the *Elektrotechnische Zeitschrift* a new system of applying electric power to motors in workshops. The author takes a given case of two generators. One dynamo, which may be called A, gives current at 50 volts, and the second, B, generates at 100 volts. The two dynamos are connected in series and united by three conductors, on what may be termed a three-wire system. Some of the motors to be driven are arranged across the two outer conductors. By the adoption of this method, which is explained diagrammatically, each motor can run at different speeds, and it is said that on an average a greater output can be obtained from each motor without changing the position of the brushes than that which it has to give when it is running at the smallest number of revolutions.

Electrical Section of the Franklin Institute.—We have received a copy of the *Proceedings* of the Electrical Section of the Franklin Institute, Philadelphia, from January to December, 1893. A portrait is given of Charles A. Coulomb, and the following papers are recorded: "Some Principles that must be observed in order to make a good Closed-Circuit Battery, and a New Portable Dry Cell Described in which these Principles are Applied," by Mr. E. F. Northrup; "The Migration of the Ions," by Prof. George Flowers Stradling—this is a *résumé* of researches by Hittorf and Kohlrausch on the velocity of ions in solutions of varying degrees of density; "The Chloride Electrical Storage Battery," by Mr. Herbert Lloyd, F.C.S.; "Some Interesting Peculiarities of Alternating Arc Lamps," by Mr. Thomas Spencer; "Notes on Recent Developments in Electricity Abroad," by Mr. Carl Hering; "Charles A. Coulomb and His Work," by Prof. Edwin J. Houston; "The Theory and Design of the Closed-Coil Constant-Current Dynamo," by Mr. Henry S. Carhart; and "Thoughts on Cosmical Electricity," by Prof. Elihu Thomson.

Logislation for Patent Agents.—A Select Committee of the House of Commons met on Monday to consider the Patent Agents Bill and the Patent Agents Registration Bill. Mr. T. H. Bolton was appointed chairman, and the committee decided to meet to take evidence on the 8th inst. The Patent Agents Bill seeks to amend the law relating to patent agents, by incorporating such patent agents as may be willing, and by empowering all patent agents, whether they join such corporate body or not, to elect from among themselves a council to keep the roll of patent agents and to be the governing body of the profession. The Patent Agents Registration Bill provides special facilities for the admission of patent agents to membership of the Chartered Institute of Patent Agents, and seeks to protect the public from deception by the unauthorised assumption of the title of patent agent. The promoters of this Bill state that its object is "not to create a monopoly, but to regulate the profession of patent agents in a manner similar to that in which other professions, such as those of solicitors, veterinary surgeons, and dentists are regulated."

The Government and Telephony.—In the House of Commons on Monday Sir J. Ferguson asked the Postmaster-General whether the agreement with the telephone companies had been completed or had made further

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progress, and what sum he proposed to expend out of loan on telephones in the present year. Mr. Labouchere asked whether the agreement had been under discussion for nearly two years, and whether the fact of its delay was not practically to enable the company to secure a monopoly of the telephone business in towns as against municipalities that were desirous to obtain licenses, and to provide adequate service for their localities. In reply, Mr. A. Morley said the agreement had been under discussion since June, 1892. He did not think that the effect of the negotiations had been to give the companies any further powers than they had before, or to prejudice the action of the municipalities. Considerable progress had been made with the agreement during the last few weeks, and points of difference between the telephone companies and the Post Office had been brought within such narrow compass that he believed the agreement would be laid on the table very shortly. He preferred not to give an estimate of the amount to be spent out of loan until the arrangements with the companies had been completed. No doubt applications had been made by certain municipalities, and they would be considered on their merits.

The Lauffen-Frankfort Transmission Plant.—As mentioned briefly in our last issue, the report of the Testing Committee in connection with the late electrical exhibition at Frankfort-on-the-Maine has been published. The report, in so far as the transmission of electrical energy from Lauffen-on-the-Neckar to Frankfort is concerned, has been prepared by Prof. H. F. Weber. The conclusions are summarised as follows: The transmission was over a distance of 105 miles, alternating current at from 7,500 to 8,500 volts being used for the purpose, and the conductors being bare copper insulated by oil and porcelain insulators. The efficiency of the transmission—that is to say, of the energy delivered by the alternators at Lauffen and that received in the conductors at Frankfort—was 68½ per cent. at the lowest output of the generators, and 75·2 per cent. at the highest performance. Theoretical investigations showed that the influence of capacity in long bare conductors carried in the air for the transmission of alternating currents upon the efficiency of transmission when using a periodicity of between 30 and 50 is so small that it can be regarded in the projection of transmission plants as being quite subordinate. The working with alternating currents at from 7,500 volts to 8,500 volts by the use of oil, porcelain, and air insulated conductors, extending over 60 miles, is as regular and safe as the operation of low-tension alternating currents in short conductors.

The British Association's Oxford Meeting.—We have received an advance copy of the programme for the forthcoming meeting of the British Association at Oxford, which commences on Wednesday, August 8. The first general meeting will be held in the evening of that day, at 8 p.m., when Dr. J. S. Burdon Sanderson, M.A., F.R.S.E., will resign the chair, and the Marquis of Salisbury, K.G., president-elect, will assume the presidency and deliver an address. On Thursday evening, at 8 p.m., a soirée will take place; on Friday, at 8.30 p.m., a discourse will be delivered by Mr. W. H. White, C.B., F.R.S., on "Steam Navigation at High Speeds"; on Monday evening, August 13, at 8.30 p.m., a discourse will be given by Prof. J. Shield Nicholson, M.A., on "Historical Progress and Ideal Socialism"; on the Tuesday, at 8 p.m., a soirée will take place; and on the Wednesday, the concluding general meeting will be held at 2.30 p.m. With regard to the sectional meetings, the president of Section A—Mathematical and Physical Science—is Prof. A. W. Rücker, M.A., F.R.S., and the vice-presidents are Mr. R. E. Baynes, M.A., Prof. R. B. Clifton, M.A., F.R.S., Prof. E. B. Elliott, M.A., F.R.S., and Mr. R. T. Glazebrook, M.A., F.R.S. The president of Section G—Mechanical Science—is Prof. A. B. W. Kennedy, F.R.S., M.I.C.E., and the vice-presidents are Prof. L. F. Vernon Harcourt, M.A., and Mr. Jeremiah Head, M.I.C.E., F.C.S. Prof. H. B. Dixon, M.A., F.R.S., will preside over Section B—Chemistry and Mineralogy.

City and Guilds of London Institute.—The report of the council upon the work of the institute during last year has been issued. At the Central Technical College, formerly called the Central Institute, at Kensington, the medal instituted by Lady Siemens for electrical students in commemoration of the late Sir William Siemens was awarded to Mr. J. R. Dick, B.Sc. At the Technical College, Finsbury, the number of electrical students is still considerably in excess of the number attending either of the other departments. The council state that they "could wish that the students were somewhat more evenly distributed amongst the three departments. The development of electrical industries has been very great during the past 10 or 12 years, and there is no doubt great scope for still further development in the future; there is, however, a distinct danger that this prospect may attract a superfluously large number of youths into electrical industries; moreover, the opportunities for advancement in mechanical and chemical industries are as great and as promising as in the electrical." A special course of evening lectures was delivered at Finsbury on "Secondary Batteries" by Mr. G. H. Robertson, and a special course on central stations for electric lighting was also announced, but owing to the illness of the principal it was found necessary to postpone it until the current session. Among the additions to the equipment of the college is a Mordey alternating dynamo. At the Central Technical College the dynamo-room has been enlarged and rearranged, and the plant of a model electric lighting station added; various voltmeters, ammeters, electromotors, and a dynamo have been added to the apparatus of the electrical department.

Institution Tit Bits.—As an interpolation to his paper last week, Mr. Crompton said, in reference to one of the Newcastle supply companies' cost of fuel, that "the calorific value was in the coal, but that the engineer could not get it out." A nice little shot at the expense of our American friends was given in regard to the conclusion arrived at some years ago in this country, that it is more economical to subdivide the load between smaller engines than to use one or two huge long-stroke, slow-speed engines. In this connection Mr. Crompton said that "after we had done that for two or three years the Americans rediscovered it." Then, again, in regard to Mr. Parker's recent statement that the electrical efficiency of his dynamos on the Liverpool Overhead Railway is 97·7 per cent., Mr. Crompton remarked that the explanation of that extremely high efficiency was "that the instruments were wrong." Concerning the diagram adopted at Chelmsford for the men in charge of the steam-engines to ascertain for themselves at any time at what load-factor they are driving their plant, Mr. Crompton observed that "this brings home to the man in charge of the engines that he is wasting his employer's money." Mr. Raworth, too, was in a happy frame of mind. They had, he said, one prophet in the Institution; that was Mr. Crompton. Some of his prophecies came true, some did not. The speaker had given Mr. Crompton certain tips in times past; some he had taken, others he had not. Mr. Crompton, he remarked, hit out straight; that was very kind of him. If it was a curve, it fetched Kapp; if an

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alternating curve, it fetched Mordey; if an engine, it fetched Raworth. Major-General Webber was also anxious to have a say, but as Big Ben had already chimed the half-hour he had to reserve his remarks until next Thursday, the 10th inst.; and remember, gentlemen, the chairman observed, we have only two more meetings this session.

The Epstein Company and Woodhouse and Rawson.—A circular has been issued to the creditors and shareholders of Woodhouse and Rawson United, Limited, with reference to raising additional capital for the Epstein Electric Accumulator Company, Limited. The present issue comprises £12,000 7 per cent. mortgage stock at par. This stock, together with a bonus of one fully-paid ordinary share of £1 for every £2 of stock applied for, is offered solely to the shareholders and creditors of Woodhouse and Rawson United, in consideration of the cancellation of the contingent debt of £11,000 owing by the Epstein Company to the former. Mr. Leslie, receiver for the debenture-holders of Woodhouse and Rawson United, has obtained the consent of the Court to the sale of the assets to Mr. Epstein, and now every creditor and shareholder, whose rights the Court was then, and is now, protecting, is entitled to participate in the benefits of the present proposals. The circular issued by Mr. F. R. Bluett, the secretary to the Epstein Company, states that "the directors have, subject to confirmation, completed negotiations that have been in hand for the last few weeks for the working of the United States and Canadian patents. The company owns these patents in addition to those for France, Belgium, Italy, Spain, and other countries, including India and the more important colonies. Mr. Klingelsmith, with whom the agreement has been made, was for several years general agent for the Thomson-Houston Electric Company, whose expert reported very favourably upon the cells some time ago with a view to their adoption. He was recently deputed by some American capitalists to make investigations in Europe with a view to acquiring the best battery that he could secure, and in the result he has signed a contract, subject to confirmation within six weeks by his principals, whereby they take up a sole license in the United States and Canada on terms that will give the Epstein Company one-fourth of all profits made, with a minimum of £4 per ton of lead used—a substantial deposit being paid after ratification. As the American company will commence with a working capital of not less than £20,000, this should produce a considerable income to this company."

Liverpool Overhead Railway Extension.—The Seaforth Sands section of the Liverpool Overhead Railway was formally opened on Monday, having previously been inspected and approved by Major-General Hutchinson and Major Cardew on behalf of the Board of Trade. The directors, railway officials, contractors, and others interested in the undertaking, proceeded along the line by special train from the Pierhead Station. Up to the present time the northern terminus has been the Alexandra Dock Station. The railway was from the first completed for another half-mile, to the point where the extensive carriage sheds and repairing sheds are situate, and the new portion of the line extends from this point for about 500 yards to the Seaforth Sands Station, which is close to the sands, and near the tram terminus at the Rimrose Bridge of the Lancashire and Yorkshire Railway on the Crosby-road. This extension, which has cost about £30,000, has been completed by Messrs. Holme and King, with Messrs. Pearson and Knowles, of Warrington, and the Phœnix Foundry Company, of Derby, as sub-contractors. The engineers have been Sir Douglas Fox and Mr. J. H. Greathead Mr. S. B. Cottrell, the general manager of the company having acted as resident engineer. The total length of the railway from the Herculaneum Dock Station at the south end, to the Seaforth Sands Station at the north end, is a little over six miles, and nearly £600,000 has been expended in its construction and equipment. The next extension of the line will probably to the Seaforth Station of the Lancashire and Yorkshire Railway—about half a mile away—and in the event of such an extension being decided upon, an exchange station will be erected there. At present there are no fewer than 14 stations on the six miles of electric overhead railway, and it is proposed to open three new stations on the existing system—between the Clarence and Sandon Dock Stations, the Sandon and Canada Dock Stations, and the Brocklebank and Alexandra Dock Stations. At a dinner which was given on Monday, the chairman, Sir Wm. Forwood, said that the line was admitted to be the greatest achievement of electrical science of the present day. Therefore he felt that the people of Liverpool had just cause for pride, inasmuch as they were the originators of the first steam railway from Liverpool to Manchester, and now the originators of the first *bonâ fide* electric railway.

Magnetic Property of Discharges of Static Electricity.—An article by Mr. H. Zielinski on the magnetic property of discharges of static electricity appears in the *Elektrotechnische Zeitschrift* of April 26. With regard to the practical application of the magnetic properties of electrical discharges, the author says that it is desirable to possess an apparatus which after each thunderstorm will indicate whether the discharge has passed to earth through the lightning conductor—that is to say, whether the installation of protectors has been damaged and requires rearrangement. He describes various appliances devised for this purpose, but which he considers are not absolutely to be depended upon. The ideal lightning indicator in his opinion is one which under all conditions will only come into operation on an atmospheric discharge, but which will not be influenced by electric currents no matter their strength. An apparatus claimed to fulfil this condition is described. It consists of a circular box provided with a movable glass lid and a metal cover to protect it against damage. Swinging on a steel point is a series of magnet needles, of which a convenient number can be magnetised. In the apparatus described and illustrated the magnet system has the form of a 12-pointed star. The box is suitably fixed to the lightning conductor, and care is to be taken that the suspension point of the needle is such that a galvanic current passing along the conductor will deflect the needle. The glass cover has on its inner surface a mark, and a corresponding mark is arranged on the magnet system. The apparatus is fixed in such a manner that the mark on the glass lid covers the one below. If now an atmospheric discharge passes through the conductor, the magnetism in the needles is destroyed, and new magnetism is produced in the star in the direction of the lines of force of the discharge. Under the influence of the earth's magnetism, or of the lightning conductor itself in case this is of iron, the star magnet will then turn a certain angular distance and remain in the fresh position taken up. The marks which previously covered one another now appear crossed. If at the close of the storm the marks are observed to be crossed, that proves that the lightning conductor has led an atmospheric discharge to earth. In this case it is only necessary to again turn round the glass lid so that the marks cover one another once more, and the apparatus is then ready to indicate another discharge. The apparatus is very sensitive, and is said to be very reliable.

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DESTRUCTIVE EFFECTS OF ELECTRICAL CURRENTS ON SUBTERRANEAN METAL PIPES.

This is the title of a lengthy paper which has just been read by Mr. Isaiah H. Farnham before the American Institute of Electrical Engineers. The subject possesses a much greater immediate interest in America than it does here, because of the extensive use there of electrical energy for tramway purposes. It was in 1891 that the author of this paper first attributed to electrolytic action the corrosion which was found upon, or in, some lead-covered telephone cables used in Boston. He says:

"A few months later the lead covering of a cable (No. 208), resting upon the ground in manhole chamber No. 76, at the corner of Berkeley and Newbury streets, was found eaten entirely through at the point of contact with the earth. I then felt certain the cable had been destroyed by the action of the current. With Mr. W. I. Towne, my assistant, I proceeded to prove the theory.

"We took measurements between the cable and the earth, the cable having been repaired and raised from the ground, and found 1·5 to 2 volts difference of potential, the cable being positive to the earth. A barrel of earth was procured from an excavation in the street, a metal plate placed beneath the earth in the barrel, and two short pieces of lead cable placed side by side on top of the earth. The plate in the bottom of the barrel was then connected to the negative side of a storage battery giving four

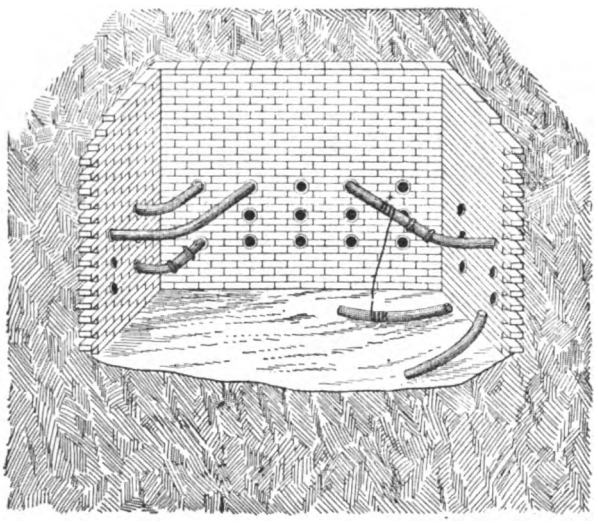

Fig. 1.

volts potential, and one piece of the cable lying on the earth was connected with the positive pole of the storage battery. The second piece of cable in the barrel was left without electrical connections. The earth was then saturated with water, and the circuit was closed, allowing the current to pass from battery to cable, to earth, to plate, and to battery, for seven consecutive days. The pieces of cable were then removed, and the piece which had been connected with the battery was badly pitted, closely resembling the cable which had been destroyed, while the second piece of cable showed no corrosion whatever, proving conclusively that a current such as was found in the manhole was sufficient to cause the damage that had been found, and that the corrosion was not, in the case of the experiment at least, due to any acid or salts in the earth.

"In addition to the experiment just mentioned, we placed in the bottom of manhole chamber No. 76, two short pieces of cable, one of which we connected by a wire to cable No. 208, which had been damaged by electrolysis and subsequently repaired. At the end of six weeks, the pieces of cable were removed and examined. The one which had been connected with cable No. 208 was deeply pitted, while the other piece was free from corrosion." The arrangement of the manhole when this test was made is shown in Fig. 1.

It is all very well, however, to detect corrosion, but proof that the corrosion was due to electrolytic action—and to electrolytic action because of the tramway system—was important; hence a series of measurements was made to obtain the voltage and direction of current, if any, between the cable in the manholes and the earth near the cables. The voltage was found to vary from the cables being negative to earth with a pressure ranging from zero to two volts, the cables being positive to earth to the pressure ranging from zero to 12 volts. These measurements afforded a convincing proof that the electric tramway was the source of the troublesome currents.

The author makes the pertinent remark that "the danger of electrolysis is only where the current is leaving the cable from pipes through the moist earth," therefore it was easy to ascertain what he termed the danger district. Of course, the important problem is to remedy the evil, once having proved it to exist, and the remedies suggested have been many and varied. Of the suggested remedies the author speaks as follows:

"First: It was proposed to remove all cables from the wet bottom and sides of the so-called manholes. It was found very difficult to place and retain cables free from the wet sides, and even could this have been accomplished, the action at the mouth of the ducts and within them would still have continued. They were, however, all removed from the bottom of the manholes.

"Second: It was suggested that the cables might be connected to ground-plates in the manholes, and so transfer the electrolytic action to these plates, and thus save the cables. This experiment was tried on an extended scale, but though many ground-plates having a surface of several square feet each were connected with the cables over a large portion of the city, it was found that voltmeter readings taken between the cables and a point on the earth a short distance removed from the ground-plate in any manhole gave nearly the same pressure as before the ground-plates were connected.

"In some cases the voltage between the cables and the earth was reduced 25 per cent.; in many others no noticeable reduction was made. The ground-plates were

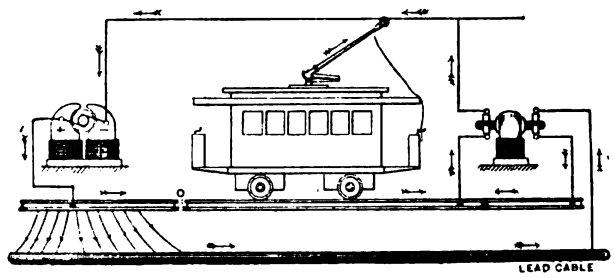

Fig. 2.

constructed from pieces of old lead cable, 6ft. to 10ft. in length, and embedded in the wet earth at the bottom of the manholes. It was evident from this test that ordinary ground-plates would not prove of material advantage for protecting the cables.

"Third: Prof. Elihu Thomson suggested, among other possible remedies, the placing of motor generators at different points along the railway line wherever the cables and pipes are found to be in danger, the motor generators to be operated by the railway power current, the secondary current developed by these generators to be utilised to lower the potential in the cables and pipes to zero with respect to the surrounding earth or rails. The suggestion included means for automatically starting and stopping the generators, as cables might become positive or negative to the rails. The motor generators would, so to speak, pump the current out of the cables and force it into the rails whenever the potential of the former should rise above zero. This plan has not yet been put into operation so far as I am aware. [Fig. 2 illustrates this suggestion.]

"Fourth: Insulating the cables and pipes from the earth was proposed. As some of the worst cases of corrosion of cables by electrolysis occurred where they were painted with asphalte, taped, painted again, and finally covered with a heavy braiding also saturated with asphalte, it was apparent that to insulate cables sufficiently to protect them would be difficult and expensive, if, indeed, practically

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possible. To protect water and gas pipes by a sufficient insulating jacket was seen at once to be impracticable.

"Fifth: Breaking the metallic continuity of the cable sheath and pipes was proposed. From the fact that severe action is frequently found in comparatively isolated spots where cables and pipes cross each other or pass near or across the rails, it follows that any system of breaking the metallic continuity would have to be studied with reference to the entire complicated system of pipes, cables, and rails ramifying through the streets of a city. There would also be a difference of potential between the several sections of cable or pipe, severed metallically, tending to cause electrolysis at one end of each section, as illustrated in Fig. 3. In case of water-pipes treated in this manner, the action might be expected on the interior as well as on the exterior.

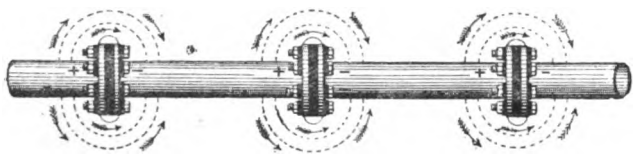

FIG. 3.

"There appears to be some evidence of such an action as this in gas and water pipes where the electrical continuity is partially broken by leaded joints. The action is most severe at points immediately on either side of the coupling. The reason the corrosion appears on both sides of the coupling in this case is not clear; it may be due to reversal of current on the railway system.

"Sixth: My assistant, Mr. Towne, suggested that the railway current might be so frequently alternated as possibly to prevent serious action on the pipes and cables. The theory was that before the oxygen gas liberated by the current should have time to attack the metal the reversal of the current would disperse it. [This plan was soon discarded.]

"Seventh: At about this stage in the study of the problem, Mr. Fred. S. Pearson, then engineer of the West End Street Railway Company, made two suggestions which, though separate in themselves, and presented at different dates, yet carried out in conjunction, have proved exceedingly helpful in overcoming the difficulty, at least, so far as relates to telephone cables. It occurred to Mr. Pearson first, that if the railway current should be reversed so that the positive pole would be connected with the trolley, the danger of electrolysis would be removed from the greater and more scattered portion of the city, and be brought near the power stations, where it possibly could be more easily dealt with. This reversal was made,

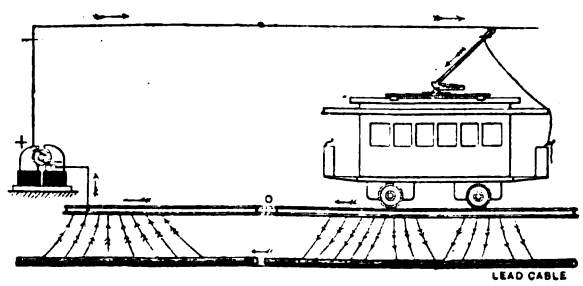

FIG. 4.

and the expected potential changes between cables and earth followed. The safe and unsafe areas were now reversed, the only variation being that by the reversal the neutral or zero line was thrown out a little further from the power-house than it was before. It was also noted that the cables near the power-house which had been from one to two volts negative to earth before the change of current, were now one to nine volts positive to earth—that is, they were raised higher above zero than they had been below zero prior to the reversal. Fig. 4 is a typical representation of the current flowing through trolley, car, rails, and cables at this time.

"Mr. Pearson next suggested the plan of running out large copper conductors from the negative side of the dynamo and extending them through the dangerous district, connecting them at frequent intervals to the cables. Fig. 5 diagrammatically illustrates this plan. On the principle involved in Prof. Thomson's motor generators, this low-resistance conductor connected directly to the dynamo was to pump the current from the cables, and so prevent its passage into or through the moist earth. Some of us were sceptical as to the completeness of this proposed remedy. It seemed possible that even with such a good return conductor, some of the current might still pass into and through the earth. Voltage measurements, however, at once dispelled the doubts, for we found that the cables measuring nine volts positive to earth gave a reading of 22 positive to the return conductor—that is, the return wire, as relating to the cables, was at all points more negative than the earth—if we may be allowed the expression. The return conductors were made up of a large number of No. 18 copper wires formed into cables about 1in. in diameter, known as conductors of 500,000 circular mils. These conductors were extended in each direction from Albany-street power-house entirely through this dangerous district, its longest section being about 5,300ft. The cables in every manhole within the district were connected by several No. 12 copper wires to the return conductor and soldered. On first connecting the cables to the return conductor, which took place December 24, 1892, the current was sufficient to melt several strands of No. 12 wire. A measurement for current flowing in the main return conductor, which was used for relieving the cables only, gave about 500 amperes.

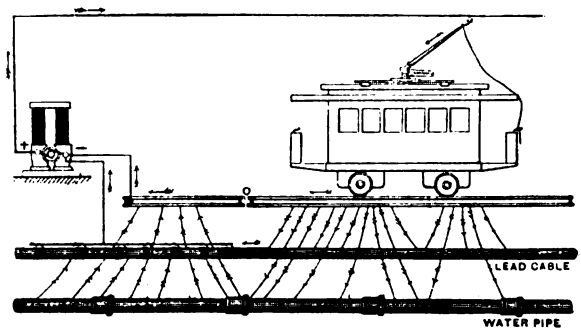

FIG. 5.

"The cables are all negative to earth. The remaining dangerous sections were corrected by taking similar means of reaching the power-house. In treating this latter case, many measurements were made to determine whether or not the railway return wires put up to take the current in a measure from the tracks would answer for a return for the cables, instead of using a special return conductor, as has been employed at the Albany-street district. It was found that they would not answer, since the potential of these track return wires varied constantly and was frequently above that of the earth.

"The cables on the Boston side of the draw of West Boston Bridge, proved to be positive to both the rail and the water, while on the other side of the narrow draw the opposite condition existed, showing at once that it was unsafe to assume any neutral lines or potential difference, without making measurements to determine the absolute facts.

"So far, this paper has dealt particularly with the subject of protection of lead-covered cables. It might be inferred that water and gas pipes can be treated in precisely the same manner with the same results, or as water-pipes have a much greater sectional area of metal, it might be presumed that simply a connection of such pipes to the dynamo at the power station would be sufficient to bring their potential down to zero throughout the dangerous district. The facts so far coming to our notice would materially modify such inferences, and therefore should find a place here.

"That iron pipes are as truly subjected to the corrosion as lead need not be stated to the members of this society, but for the benefit of city officials and others who may read the paper it should be plainly stated that they are quite as readily destroyed by electrolysis.

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"Mr. Benzenberg writes that the trouble in Milwaukee was chiefly noticed upon the 6in. water-main extending 100ft. on each side of a point opposite the railway power station. Services entering this main were also destroyed, and all were renewed three times during the past two years. He states further, and I quote his own words, 'at other points where power-houses were established thereafter, the mains were immediately connected by extra heavy copper wires with the generator; we have had no trouble with them so far.'"

Other interesting information, principally about water-pipes, was given, and the author concluded his paper as follows:

"When all cables and pipes in the danger district are connected by sufficiently large conductors to drain them, a careful adjustment in resistances in these several conductors may be found necessary in order to ensure a balance between the several systems of pipes. It may lead to the necessity of reducing the carrying capacity of the conductor returning to the dynamo from the rails themselves.

"The question has already arisen, and it doubtless will be repeated here, 'How small a difference of potential between pipe and earth will cause electrolytic action?' In reply to this, it may be stated that some of the worst cases of corrosion in Boston have occurred where the difference was but $1\frac{1}{2}$ volts. Mr. A. T. Wells, of Chicago, in describing to me an examination of some of the first cases in Cincinnati, states that the 'difference of potential between the cables and the rail was never more than one-half and usually less than one-quarter volt.' Such a difference between cable and rail would mean a much less difference between cable and earth where electrolysis takes place. Mr. John C. Lee, of Boston, has experimentally caused the corrosion on lead and iron by a difference of potential of $\frac{1}{100}$ volt.

"These facts certainly indicate that but a very small pressure is necessary to produce the action, and should dispel the numerous statements that well-bonded rails or a large amount of rail return wires will alone overcome the trouble. In some cities where electrolysis is in progress to-day, the return copper nearly equals that of the trolley feed-wire system. We cannot force the current to take one path exclusively when others are open to it.

"The facts given above, with others similar, though not enumerated, lead me to these conclusions:

"1. All single-trolley railways employing the rails as a portion of the circuit cause electrolytic action, and consequent corrosion of pipes, in their immediate vicinity unless special provision is made to prevent it.

"2. A fraction of a volt difference of potential between pipes and the damp earth surrounding them, is sufficient to induce the action.

"3. Bonding of rails, or providing a metallic return conductor equal in section area and conductivity to the outgoing wires, is insufficient to wholly prevent damage to pipes.

"4. Insulating pipes sufficiently to prevent the trouble is impracticable.

"5. Breaking the metallic continuity of pipes at sufficiently frequent intervals is impracticable.

"6. It is advisable to connect the positive pole of the dynamo to the trolley lines.

"7. A large conductor extending from the grounded side of the dynamo, entirely through the danger territory, and connected at every few hundred feet to such pipes as are in danger, will usually ensure their protection.

"8. It is better to use a separate conductor for each set of pipes to be protected.

"9. Connection only at the power station to water or gas pipes will not ensure their safety.

"10. Connection between the pipes and rail, or rail return wires, outside of the danger district should be carefully avoided.

"11. Frequent voltage measurements between pipes and earth should be obtained, and such changes in return conductors made as the measurements indicate.

"In closing this somewhat rambling paper, I can do no better than use words which will remind you of Patrick Henry: 'eternal vigilance' will be the 'price' of pipes and cables where conditions favourable to electrolysis exist."

THE TRANSFORMATION OF DIRECT INTO ALTERNATING CURRENTS AND VICE VERSA.

In a recent issue of *L'Electricien* (April 21), M. Aliamet describes the system devised by MM. Hutin and Leblanc for the transformation of direct current into single or multiphase alternating currents. Fig. 1 gives a view of

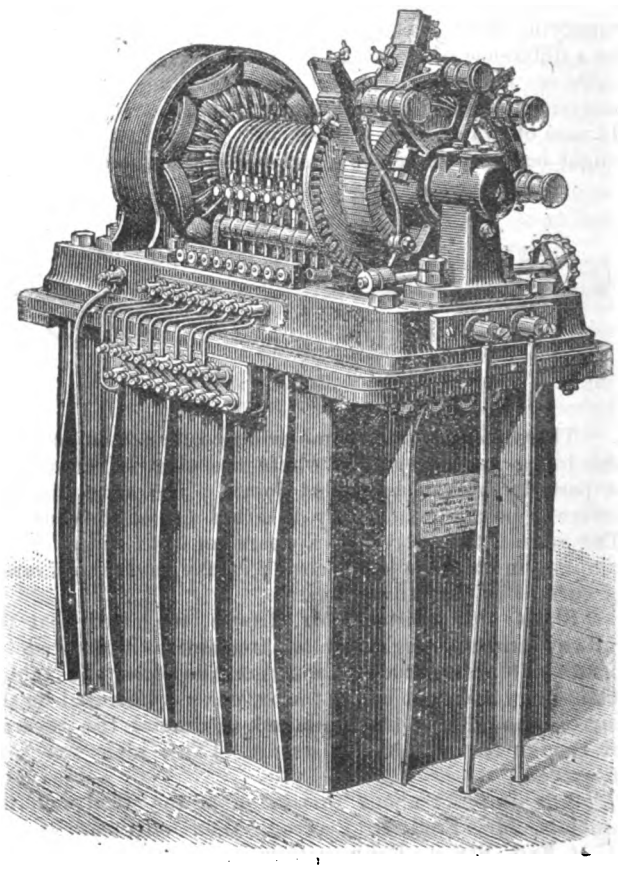

FIG. 1.

the apparatus used. A special type of alternating-current transformer is arranged in the lower part of the standard; above this is a second transformer, which is rotary and reversible, and it comprises a Gramme ring revolving in an eight-pole inductor. In addition to the usual commutator, the shaft has arranged on it a series of bronze rings insulated and provided with brushes; the latter are connected to the terminals of the coils of the primary circuit of the alternating-current transformer by means of connections shown at the top of the standard. The rings are, moreover, connected one by one to the segments of the commutator. The object of the rotary part is to change alternating currents to continuous of the same pressure, and inversely; whilst the lower transformer increases or reduces the voltage. A complete

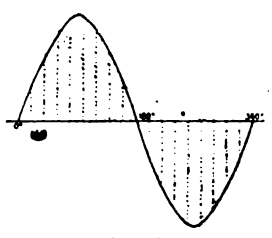

FIG. 2.

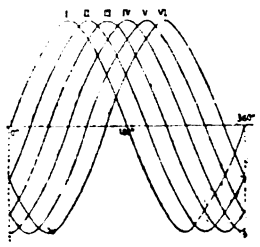

FIG. 3.

installation requires two identical apparatus: the first is the transmitter, and the second the receiver. As the principle of the revolving transformer lies in the properties of the Gramme winding, we will refer to those which more directly concern us.

Let us consider a direct-current machine with a Gramme ring, divided into an equal number, N, of sections, and moving in a uniform magnetic field at a constant speed. It is known that under these circumstances any coil occupies

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the angle $\frac{2\pi}{N}$, and that it is the seat of a sinusoidal E.M.F. of which the ordinates in Fig. 2 represent on a given scale the successive values in the duration of a period. But each section develops an E.M.F. simultaneously; all have the same amplitude and the same period, and any one differs only from its neighbours by a value $= \frac{2\pi}{N}$. If we suppose N = 6, Fig. 3 shows the E.M.F.'s displacement. By the fact of their arrangement in series, their resultant

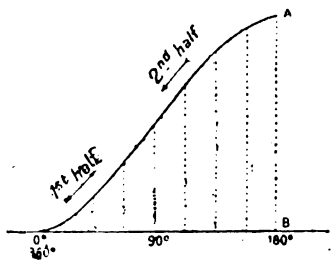

FIG. 4.

is found to be that indicated in Fig. 4. In the latter the E.M.F.'s are deemed rectified, and the successive ordinates are obtained by the integration of those in Fig. 2. The two halves of the ring, divided into two parts by the line of commutation, produce the same resultant; the second is superposed to the first, and arranged, consequently, in opposition to it. When we desire to collect the current, the brushes are placed in O and A, which give the maximum difference of potential. It is easy to see that the ordinate, AB, has not a rigorously

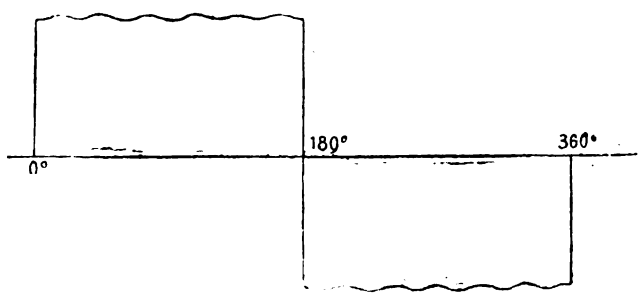

FIG. 5.

constant length. In fact, there is produced an undulation in the value of the resultant E.M.F., and it is found to be all the more marked as the number, N, is smaller. The current naturally presents corresponding variations, but the self-induction of the ring weakens them; they are, moreover, made to sensibly disappear by increasing the section of the coils.

According to the method of utilising partial E.M.F.'s, we can obtain from the Gramme winding a series of different currents. In the ordinary case, the current is continuous in the external circuit and simple alternating in the ring, as represented in Fig. 5, and if the circuit is opened no

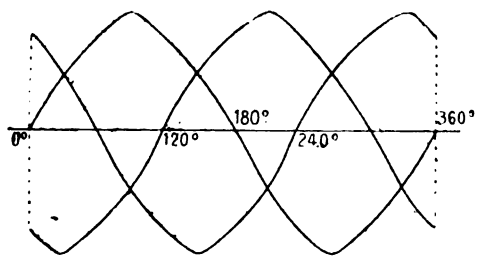

FIG. 6.

current is produced. If we now place on the shaft a certain number of insulated metallic rings (for instance, three) connected to these sections situated 120deg. from each other, we shall obtain in this case triphase currents which will circulate both in the ring and in the three-wire circuit, as in Fig. 6.

To resume, a Gramme ring provided with its collector and a system of rings can give as a generator either simple or polyphase alternating currents or direct current, or both together. These same currents brought to the ring properly will cause it to run as a motor. By furnishing direct current to the brushes of the transmitting appliance it will produce alternating currents, which will be conveyed to the receiving transformer by connecting the two apparatus with as many line wires as there are rings to one of them. The receiving transformer, revolving under their action, will give in the circuit of the brushes a continuous current. In order that the running may be effected without sparking, there must be absolute synchronism between the N E.M.F.'s developed in the transmitter and the corresponding counter E.M.F.'s produced in the receiving transformer.

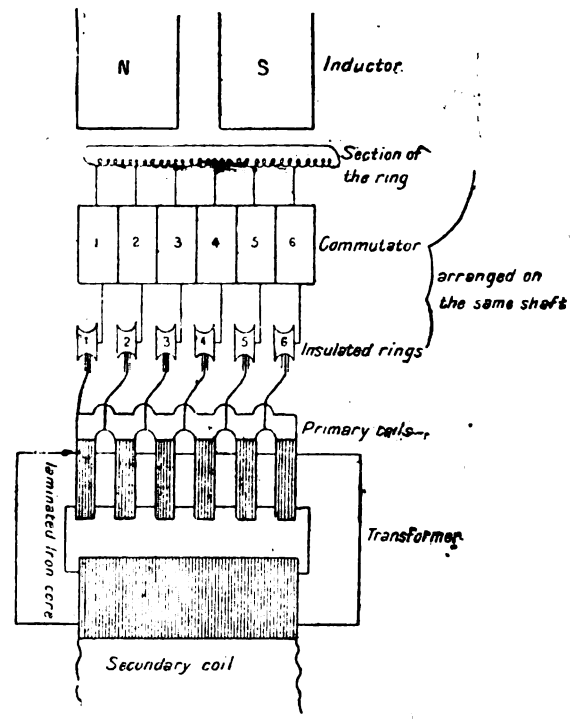

FIG. 7.

The rotary transformer devised by MM. Hutin and Leblanc is represented diagrammatically in Fig. 7. The sections of the ring are arranged in shunt with the primary coils by means of insulated rings and brushes. As it is mainly in the primary circuit that the currents rendered into alternating by the rotation of the commutator should circulate, the ring is of small dimensions because it must only overcome the friction of the brushes. The rings and

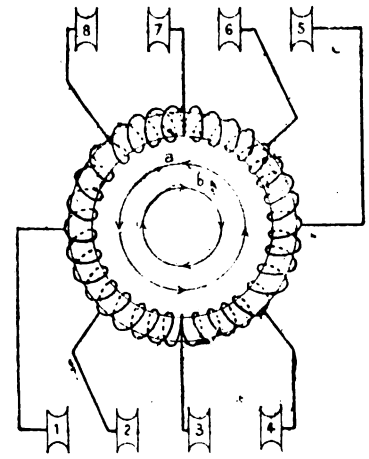

FIG. 8.

the commutator are made rather large to carry all the current. In fact, the latter is distributed between the ring and the primary coils proportionately to the apparent resistances of these two circuits. Thus the transmitting ring revolves as a direct-current motor, but the receiving apparatus works as an alternating-current motor.

The pressure transformer consists in principle of an ordinary transformer with a closed magnetic circuit. The

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primary is formed of fixed coils connected in shunt with the sections of the ring already mentioned, Fig. 7. All the coils are arranged in series and constitute a closed circuit; the first half is wound in one direction and the remainder is wound in the opposite direction. Fig. 8 shows the primary formed in this manner. This precaution has been necessary for the following reason: if the winding was arranged in the same direction from one end to the other, we should have generally an immovable Gramme ring traversed by a current passing successively through all the groups and the two opposed sections. The result

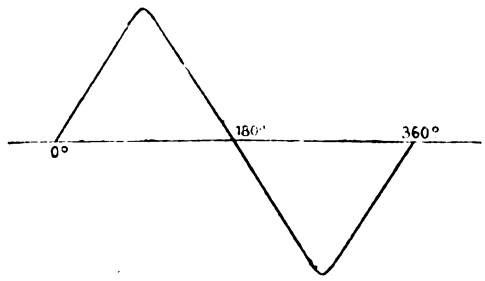

FIG. 9.

would be that the flux would always be in the same sense, and no induction would be obtained in the secondary, *a*. By opposing one half of the coils to the other, the flux passes through the iron in one direction, *a*, during a half period, and in the opposite direction during the following half, *b*. Thus the production of the secondary E.M.F. is assured. The curve given in Fig. 9 shows the variations, the number of turns of each primary section being the same, and the feeding alternating current having the form shown in Fig. 5.

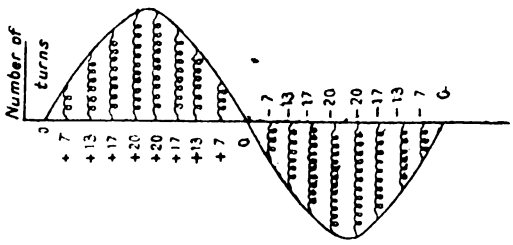

FIG. 10.

In view of other applications, MM. Hutin and Leblanc made the primary of their experimental transformer with coils in which the number of turns varies from one section to another, following a sinusoidal function of time. The ordinates given in Fig. 10 represent by their length the number of relative turns. It is, moreover, evident that with the necessity of getting enough ampere-turns to create a sufficient flux in the secondary, we shall be able to increase the number of turns in the elementary coils in a

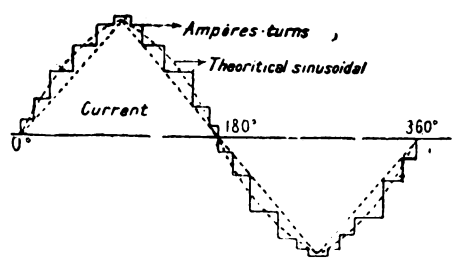

FIG. 11.

given ratio. The object of this special winding is to be able to feed the primary, not solely with an alternating current from a Gramme ring, but also with that of an ordinary type of alternator. It was then necessary to make the curve approximately sinusoidal, Fig. 11.

Let us now examine why only two or three conductors need be used for the line, no matter what is the number of sections of the ring. If there is only one magnetic circuit, the secondary current will be a simple alternating current, and only two wires will be necessary. If, however, it is desired to produce triphase currents the magnetic circuit must have three cores. The three primaries will be identical, but connected, as shown in Fig. 12. The flux is thus displaced 120deg., or a third of a period, and the three secondaries connected so as to produce the arrangement represented in Fig. 13, will give triphase currents which these wires will suffice to convey to the receiving transformer.

We have already seen that the rotary transformer moves according to the alternating current traversing it; if the latter was single-phase, we should be compelled to start the ring by hand, and once in operation it would be liable to stop. Thus, in order to ensure certainty of working, recourse must be had to the use of polyphase currents. By the use of triphase currents sent along the line, the low-tension circuit of the receiving transformer also furnishes three-phase alternating current at the receiving ring. The latter is then in a position to start, and will maintain its speed

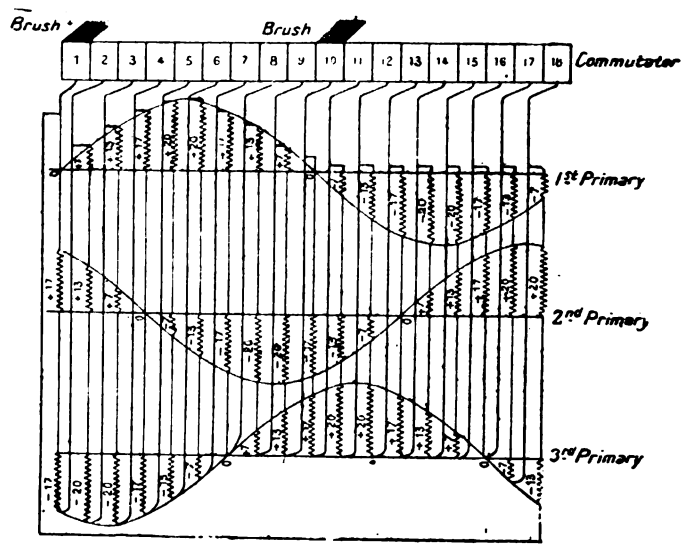

FIG. 12.

without being subject to stoppages. The commutator of the receiving transformer rectifies a single alternating current as well as a multiphase current.

The condition of synchronism being absolutely necessary, the inventors have not been content with an approximation given by the mechanism of the revolving field. To completely avoid sparking at the brushes of the commutator of the transmitting transformer and of the receiving transformer, a synchronising apparatus, arranged on the pole-pieces as in Fig. 14, is used. It will be seen that holes are drilled through the sheets forming the magnetic circuit of the field. These holes are fitted with light insulating material, and copper rods are passed through them. The ends, which are placed on the same side, are riveted to bronze frames which maintain the sheets, Fig. 14A, in such a manner that the "electros" are furnished with a closed circuit of little resistance. The copper rods are as numerous as possible.

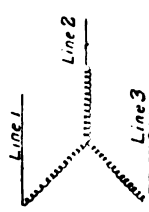

FIG. 13.

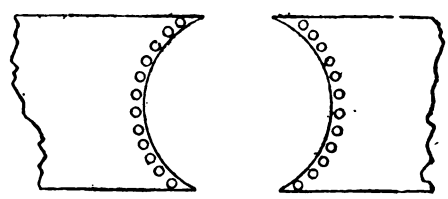

FIG. 14.

To facilitate the comprehension of the working of this method let us consider a Gramme ring revolving in a magnetic field of fixed position; the feeding currents are triphase and brought by three rings, as represented in Fig. 15. Suppose the ring is at work: the resultant field produced by the three-phase currents is A B. This bearing turns round the centre, *o*, in the direction of the arrow, F, for instance, and at a speed equal to the frequency, Ω. We will let the rotary movement of the ring be accomplished; it will be inverse to the direction, F, and its speed yet equal to Ω (when there is synchronism). But the ring takes with it the productive circuits of the rotary field in

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such a manner that the direction, A B, induced by two inverse and equal movements (Ω and $-\Omega$) remains motionless in the space, making a determined angle, α, with the direction of the inductive field. As the moderating circuit results in a ring winding put in short-circuit, it will be easily conceived that the tendencies to oscillate from A B are completely and instantly overcome by the reaction of the intense currents that its displacement creates in this moderating circuit. In reality everything takes place as if the field, A B, had to be displaced in a very viscous medium. This explanation rests upon the admitted hypothesis that the ring revolves in the inverse

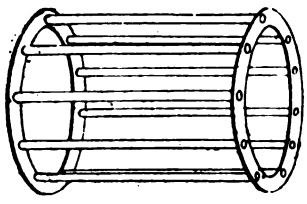

FIG. 14A.

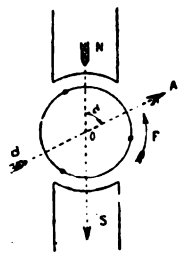

FIG. 15.

direction to the field, A B. We shall see that, if this movement was in the same direction, we could not have a motive couple. In effect, in order that relative displacement between an induced field and an inductive field may take place, it is necessary that their bearings should constantly tend to superpose without ever actually doing so. In a direct-current motor even the play of the commutator counteracts perpetually this tendency in motors with a revolving field; the armature, which always has to overcome at least its own passive resistances, can never revolve as quickly as the inductive field. Finally, in the motor under consideration and which has an inductive field of constant direction, it is the immobility of the resultant, A B, which maintains the desired angular movement.

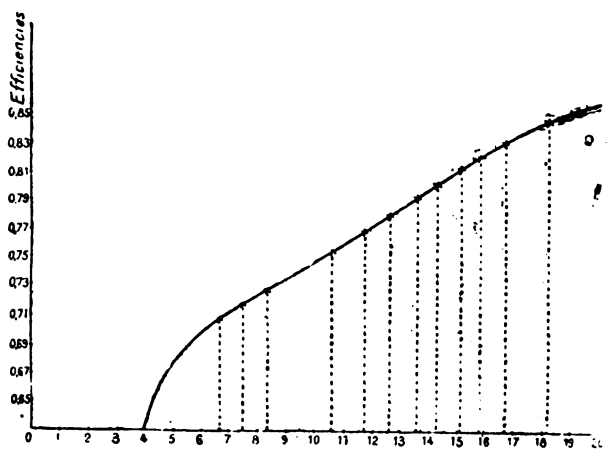

FIG. 17.

The action of this apparatus is such that it is possible to pass, roughly, from no load to full load without the production of sparking. If desynchronisation could take place, the brushes would be immediately melted. In order that the running may be good, a synchronising apparatus must be placed both in the transmitting and receiving transformer. The brushes are automatically placed, and in reality they are fixed once and for all.

It will be seen from Fig. 16 that the motor has eight poles; the commutator is, therefore, quadruple, and, as there are 18 sections, it has 72 segments. It was desired to have a comparatively low speed of 1,200 revolutions, and at the same time to get a reasonably high frequency of 80 periods per second. This has necessitated the adoption of the multipolar type, and it is evident that by changing the proportions of the different pieces a good result could be also obtained with a two-pole type. In Fig. 16 a complete diagram of the apparatus is given, but the motor is assumed to be bipolar so as not to show a lot of connections unnecessary for the purpose of comprehension.

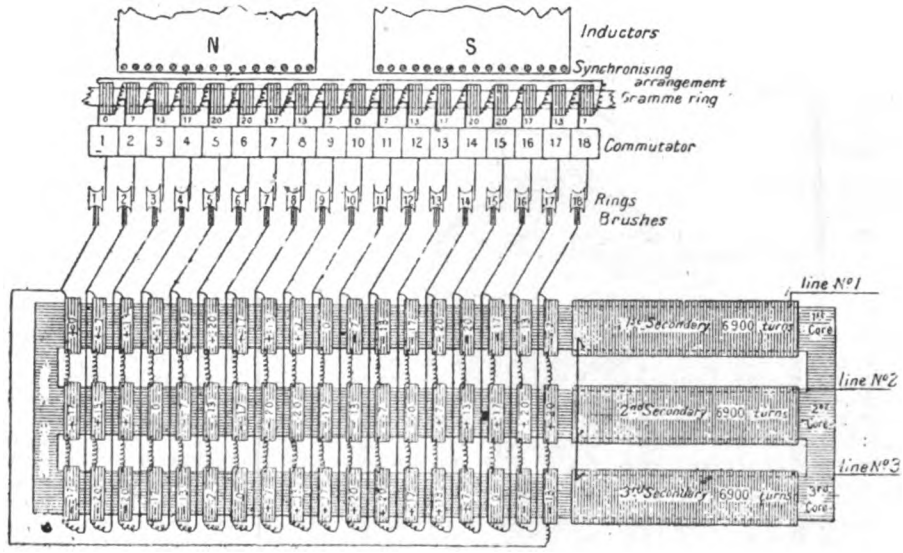

FIG. 16.

Experiments made with the Hutin and Leblanc system have given satisfactory results. The transmitting transformer was supplied at the commutator with a continuous current of 100 amperes at 200 volts. This was converted into triphase currents, and conveyed along a bare copper line at 6,000 volts. At the receiving end the current was transformed into direct current, which was used to charge accumulators. In Fig. 17 is given a curve showing the efficiency of the systems as found in the experiments.

SEARCH-LIGHTS FOR CANALS.

In a previous issue we referred to the improved search-light plant introduced by Messrs. Baxendale and Co., of Miller-street, Manchester, for use on vessels navigating the Manchester Ship Canal at night. The plant, which is portable and always ready, comprises a small engine and dynamo combined, a search-light projector of the Admiralty pattern, and a mast arc lamp and reflector. The apparatus is of similar type to that which has been used for over 12 months for lighting vessels through the Suez Canal, where it has proved most effective and very satisfactory.

Our illustration represents one application of the search-light. The projector is shown mounted in a portable cage with an adjustable resistance on the left-hand side, and it is arranged to be fixed on the stems of vessels, the cage being suspended from a davit or spar, and clipped by the cramps attached to the cage. The projector barrel is 20in. diameter, rolled out of steel sheet, all the mountings being of gun-metal finished bright. The mirror is one of Messrs. Chance Bros.' best quality, 20in. diameter, 10in. focus, fitted in brass frame with a bayonet socket attachment to the barrel, so as to facilitate removal for cleaning, etc. A dispersing lens, also by the same firm, having an angle of divergence from 7deg. to 30deg., is attached by means of a hinged frame to the forward end of the barrel, in order to fantail the light, so as to spread it on the canal banks. The barrel is fitted with screw gear for focussing the lamp, and with worm and worm-wheel for vertical movement, and faced flanges on pedestal for horizontal movement. The electrical connections are carried inside the projector, and an instrument similar to a camera is provided at one

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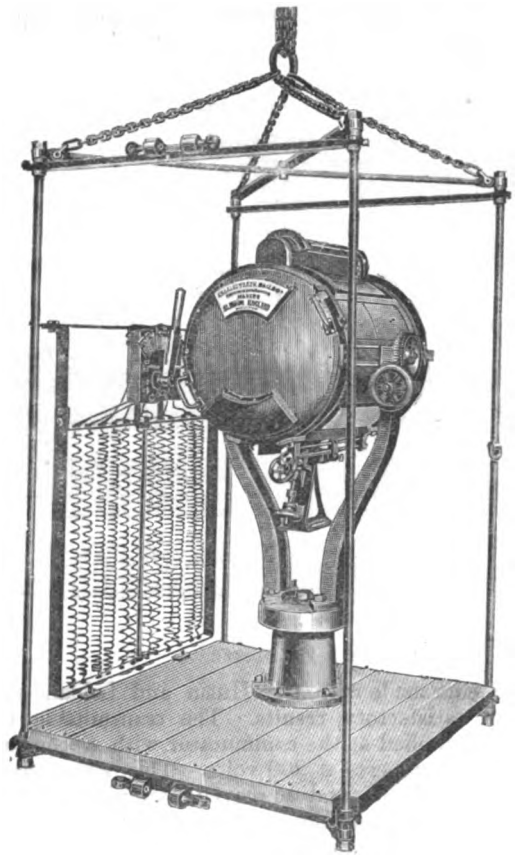
side of the projector for viewing the arc image thrown on ground glass. The hand lamp is made detachable, and is quite independent of the projector itself, the feed of the carbons being obtained by a right and left hand thread screw in the usual way, with a screw for raising and lowering the carbons. With carbons 25mm. diameter and a current of 50 amperes, this projector will illuminate a distance of 1,400 yards. A small combined engine and dynamo of the type supplied by Messrs. Hall and Co., of



Oldham, direct coupled, running at 500 revolutions per minute, with an output of 65 volts and 50 amperes at a steam pressure of 75lb. per square inch, are provided for working these projectors, with two attendants and the necessary accessories for working.

THE RELATION OF MATHEMATICS TO ENGINEERING.*

BY JOHN HOPKINSON, D.SC., F.R.S., M.I.C.E.

Mathematics has been described in this room as a good servant but a bad master. It will be my duty this evening to prove by suitable illustration the first half of the proposition, and to show the service mathematics has rendered and can render to engineers and engineering.

In our charter the Institution of Civil Engineers is defined as "A society for the general advancement of mechanical science, and more particularly for promoting the acquisition of that species of knowledge which constitutes the profession of a civil engineer, being the art of directing the great sources of power in [nature for the use and convenience of man, as the means of production and of traffic in states both for external and internal trade, as applied in the construction of roads, bridges, aqueducts, canals, river navigation and docks, for internal intercourse and exchange, and in the construction of ports, harbours, moles, breakwaters, and lighthouses, and in the art of navigation by artificial power for the purposes of commerce, and in the construction and adaptation of machinery, and in the drainage of cities and towns." No better definition can, I think, be found for our profession than that it is the art of directing the great sources of power in nature for the use and convenience of man. It covers all that the widest view of our work can include, and it excludes those applied sciences, such as medicine, which deal with organised beings. Mathematics has to deal with all questions into which measurement of relative magnitude enters, with all questions of position in space, and of accurate determination of shape. Engineering is a mathematical science in a peculiar sense. Medicine, the other great profession of applied science, has but little to do with questions of measurement of magnitudes or of geometry; but the engineer finds them enter into everything with which he has to deal, and enter in the most diverse ways. The thing he has to determine is that the means he employs is enough, and not unnecessarily more than enough to attain the end in view. For this he must numerically measure the end and the means, and see that they are justly proportioned to each other. It is useless this evening to waste time proving, what all will admit, that no one can be even the humblest engineer without a knowledge of arithmetic and enough of geometry to enable him to read a drawing, that some trigonometry, some rational mechanics and a knowledge of projections, is a very useful part of the mental equipment of a draughtsman. It is hardly necessary to call attention to the great economy in the labour of calculations effected by the use of logarithms, a mathematical instrument for which we are indebted to Napier. We may with more profit examine what use the higher mathematics can be to the practical engineer, and what has been done in the past for engineering by its aid.

Judging from etymology, mathematics must have been begun by engineers, for surely geometry is the work of the earth measurer or land surveyor. But since the prehistoric times when geometry was initiated, engineers have not added much that is new to mathematics. They have rather sought amidst the stores of the mathematician and selected the handiest mathematical tool they could find for the particular purpose of the moment, but have done little or nothing in return in the way of improving the tools which they borrow. In this respect the relation of engineering to mathematics differs much from its relation to experimental physics. In electricity, magnetism, and heat, engineers have from their practical experience repeatedly corrected the ideas of the theorists, and have started the science on more accurate lines. If our subject to-night had been the use of the practical applied science of engineering in promoting the development of pure mathematics, we should speedily find that there was hardly any material for discussion. The account being all on one side, let us see to what the debt of the engineer to the mathematician amounts.

There is no department of practical engineering in which the application of mathematics is more familiar than in that which relates to the calculation of the strength and rigidity of structures of various kinds. It is impossible to take up any book dealing with the subject without finding that it is crammed either with mathematical formulæ or with geometrical figures. The question is not whether mathematics is necessary to an adequate comprehension of the subject, but whether analytical or purely geometrical methods are more convenient. Of course, one might occupy many lectures in discussing the practical application of mathematics to the question of bridge building, roofs, guns, shafting, and the like. Our object must be to illustrate by various examples rather than to attempt anything like a complete discussion.

Consider the case of a long strut, so long that its transverse dimensions can be regarded as insignificant in comparison with its length. Whilst the strut remains perfectly symmetrical about its middle line, its strength will depend only upon the resistance of the material to crushing. Everyone knows that this would be an inadequate conclusion; we have to consider another element, namely, its stability—that is, we must examine what will happen to the strut if from any cause it is displaced somewhat from the direct line between its extremities. A mathematical discussion of the question results in a differential equation of the second order with one independent variable. Upon consideration of this we are enabled to see that if the thrust upon the strut be less than a certain critical value, a slightly bent strut will tend to return to its straight condition; but that if the thrust upon the strut be greater than this critical value the displacement will tend to increase, and the strut will give way. Further, that the critical value will depend upon whether one or both of the two extremities of the strut are held free, or whether they are rigidly attached by flanges or otherwise, so that the direction of the axis of the strut at this point must remain unaltered. Again, we infer that if the ends are held rigidly fixed, the length of the strut may be twice as great for a given critical value of the thrust as if the two ends are free to turn. We can also infer what the critical value will be for struts of various lengths and of varying cross-sections. This critical value depends not upon the resistance of the material to crushing, but upon its rigidity.

Another example, having a certain degree of similarity with the case of struts, is that of a shaft running at a high number of revolutions per minute, and with a substantial distance between its bearings; for simplicity, we will suppose that there are no additional weights such as pulleys upon the shaft. How will the shaft behave itself in regard to centrifugal force as the speed increases? In this case, so long as the shaft remains absolutely straight it will not tend to be in any way affected by the centrifugal force, but suppose the shaft becomes slightly bent, it is obvious to anyone that if the speed be enormously high this bending will increase, and go on increasing until the shaft breaks. In this case also we may use mathematical treatment; we find that the condition of the shaft is expressed by a differential equation of the fourth order, and from consideration of the solution of this equation we can say that if the speed of any particular shaft be less than a certain critical speed, the shaft will tend to straighten itself if it be momentarily bent, but that, on the other hand, if the speed exceeds this critical value, the bending will tend to increase with the probable destruction of the shaft. I do not know that either of these two questions can be properly understood without some knowledge of differential equations.

A problem having a certain analogy to those to which I have just referred is that of hollow cylinders under compression from without, such as boiler tubes. Whether the tubes be thick or

* The "James Forrest" lecture, delivered before the Institution of Civil Engineers, May 3, 1894.

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thin, so long as they are perfect circular cylinders, they should stand until the material was crushed. But if the tubes are thin, what will happen if the tube from any cause deviate ever so little from the cylindrical form? The solution cannot be obtained without a substantial quantity of mathematics.

The next illustration shows how a mathematical conclusion, correct within the limits to which it applies, may mislead if applied beyond those limits, and how a more thorough mathematical discussion will give a correct result. Considering a case of shafting in torsion, it was shown by Coulomb that the stiffness and strength of a shaft having the form of a complete circular cylinder could be readily calculated if the transverse elasticity of the material and its resistance to shearing were known. From the complete symmetry about the axis it is evident that points which lie in a plane perpendicular to the axis before twisting will still be in that plane when the shaft is twisted; it is also clear that the angle through which all points in the same plane move will be the same; hence the problem was as simple as problem could be. But many who had occasion to make use of Coulomb's results gave them an application which was wholly unwarranted. They assumed that they were equally applicable to other cases than complete circular cylinders; they assumed, in fact, that every point of the material which lay in a plane perpendicular to the axis would remain in that plane when the shaft was twisted, whether the shaft was symmetrical about its axis or not, and they consequently arrived at very erroneous results. That the assumption was erroneous is obvious enough from a consideration of an extreme case. In Fig. 1 is shown in cross-section a hollow cylindrical shaft, which is not complete, but divided by a plane passing through its axis. In this case the shaft when twisted will be as illustrated in the side elevation; two points, A and B, were in one plane perpendicular to the axis when the shaft was free from twist; they cease to be in one plane when the shaft is twisted. St. Venant* in 1855 investigated the question of shafts without making incorrect assumptions; he expressed the condition of the material by a partial differential equation of the second order, and gave suitable surface conditions. A general solution of the problem for all forms of shafts has not been obtained, but St. Venant gives

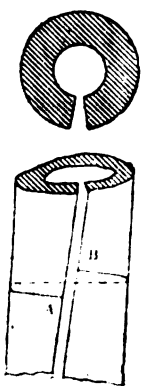

FIG. 1.

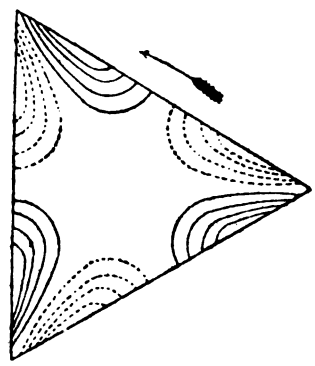

FIG. 2.

a number of solutions for particular forms, and he obtains some general results of interest. In all cases the stiffness of the shaft is less than would be inferred from an erroneous application of Coulomb's theory. Fig. 2 shows diagrammatically the strain in a shaft of triangular section; the full lines indicate that the parts of the shaft which lay in one plane before twisting, when twisted rise above the plane; the dotted lines indicate that they lie behind the plane of the paper. The shearing stress is least at the angles of the triangle, and is greatest at the middles of the sides. At this point, then, the shaft will begin to break under torsion. The fact is probably well known to men of practical experience, but it is directly contradictory to the conclusion at which one would arrive by a careless use of Coulomb's theory beyond the narrow limits within which it is applicable. The longitudinal ribs which one often sees on old cast-iron shafts are useful enough to give stiffness to the shafts against bending, but are good for very little if torsional stiffness or torsional strength is desired.

Another application of mathematical theory which has been carried somewhat further than the premises warrant is found in the case of girders. It is almost invariably customary to treat a girder as though the sections retain when the girder is bent the form and size which they had before bending. Making this assumption, it is very easy to calculate the strength and stiffness of a girder of any section. Unfortunately, the assumption is untrue; but, fortunately, it is approximately true in the case of most girders with which engineers in practice have to deal. That it is untrue can be readily seen from consideration of a girder of exaggerated form, the section of which is shown in Fig. 3. Any practical man would at once see that the outer parts of the flanges would add little to the strength of the girder, but according to the usual mathematical theory the outer parts of this flange should be as useful as the parts which are nearer to the web. This problem St. Venant also deals with in a rigid mathematical manner. Amongst other things, he showed that a girder of rectangular section, such as shown in Fig. 4, would, when bent, take the form shown by the curved lines in the same figure. The last two examples show how a little knowledge may be a dangerous thing, and how easy it is for anyone who attempts to apply mathematics without adequate mathematical knowledge to be misled.

The theory of thick cylinders under bursting stress from within has many important practical applications to hydraulic presses and to guns. It has been discussed more than once in this room. As usual in considering these cases, we are immediately led to differential equations which here are fortunately solved without serious difficulty, and the solution tells us the whole story. We learn that doubling the thickness by no means doubles the strength of the cylinder. And as a converse, that doubling the strength of the material will permit the thickness to be diminished to much less than one-half. Twenty-five years ago hydraulic presses were mostly made of cast iron. Many people were not a little astonished at the great reduction in thickness and weight which became possible when steel was substituted for the weaker material. In the case of guns it is well known that greater strength can be obtained if the outer hoops are shrunk on to the inner ones.* Mathematical theory tells us what amount of shrinkage should give the best results. It may possibly not be worth while to follow the results of theory precisely, but without the guidance of theory it would not be unnatural to give so great a shrinkage that the gun would be weaker than if no shrinkage were used.

The rolling of ships in a seaway gives an illustration of a principle which has very varied application in many branches of physics. Suppose a body is capable of oscillating in a certain periodic time, and that it is submitted to a disturbing force of given period, the equation of motion easily shows that the resulting disturbance will be great if the two periods are equal or nearly equal. We meet with the principle in acoustics as resonance. If two tuning-forks are tuned to the same pitch, and one is sounded in the neighbourhood of the other, that other will presently be thrown into vibration by the waves transmitted through the air from the first. You may try a similar experiment at any time on any piano. Strike the higher G in the treble, the sound ceases on raising the finger. Now hold down the middle C, and again strike G, the C string at once takes up the note sounded, and can be heard after the exciting string has been silenced by damping. The same fundamental idea is found in the lunar theory in the term in the equation known as the evection, and again in the theory of Jupiter's satellites. The reason why the metals present in the solar atmosphere give black lines in the spectrum by absorption, corresponding in position with the bright lines in the spectrum which the same metals give when incandescent, is again the same. Gas will absorb or take in from the ether waves of the exact period which it is capable of giving to the ether. The general

FIG. 3

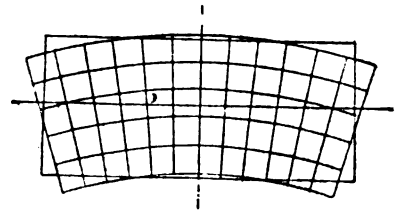

FIG. 4.

explanation of all these phenomena is easy. Imagine a pendulum, and suppose it experiences a periodic disturbing force, the first impulse of the disturbing force gives the pendulum a slight swing, the effect of the second impulse depends entirely on when it occurs—it may occur so as to neutralise the effect of the first, or it may occur so as to increase it. If the period of the force is the same as the natural period of the pendulum, the effect of the second, third, and later impulses will be added to the effect of the first, and the final disturbance will be great even though the individual impulses be minute. But the mathematical theory tells us much more than any general explanation can do. It tells us exactly what the character of the effect will be, and its amount if the periods are nearly but not exactly the same. It tells us, too, exactly how friction affects the results. And the beauty of it is that the mathematical theory is much the same in all cases, so that, having learned to deal with one case, we are enlightened as to a host of others. The oscillating body may be an ironclad, or it may be an atom of hydrogen, the disturbing periodic force may be the waves of the Atlantic, or it may be the waves in the ether occurring five hundred millions of millions of times in a second; it is all one to the mathematician, the treatment is substantially the same.

The question of the speed of ships and the power to propel them is probably more effectually treated by experiment on models, as was done by the late Mr. Froude, than by mathematics alone; but in order to learn from the experiments all they are capable of teaching a mathematical understanding is needed. Given that we know by experiment all about a given model, that we know what force is needed to propel it at every speed, we want to know from these experiments how a great ship, 100 times as big but similar in form in every respect, will behave, and here mathematics come in to aid us in making the inference.

The construction of ships at once leads us on to the methods of navigating them. In navigation I should find much material for my purpose, but navigation is not usually included in engineering, but many of the implements of navigation undoubtedly are. The mariner's compass has for ages been the mainstay of the navigator, and a simple enough instrument it was till it was disturbed by

* "Mémoires des Savants Etrangers," 1855; and Thomson and Tait "Treatise on Natural Philosophy."

* Lamé, "Leçons sur la Théorie Mathématique de l'Elasticité des corps solides." Fourteenth "Leçon."

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the iron of which ships came to be built. The disturbance of the compass by the iron of the ship was first seriously attacked by two senior wranglers, Sir G. Airy and Mr. Archibald Smith. The disturbance may be divided into two parts—the first due to the permanent magnetism of the ship, the second to the temporary magnetism induced by the earth's inductive action on the iron of the ship; the first causes the semicircular, the second the quadrantal, error. One has only to open the "Admiralty Manual of Deviations of the Compass" to see how the mathematics of Archibald Smith have accomplished a proper understanding of the subject. The errors of the compass are dealt with in two ways: they are compensated by soft-iron correctors, and by permanent magnets so placed as to have an effect equal and opposite to the effect of the temporary and permanent magnetism of the ship; or they are dealt with by formulæ of correction which enable the error to be calculated when the course of the ship and the conditions of the earth's magnetism are given, or a combination of the two methods is used. Either method is based on Archibald Smith's theory. It is not possible to leave the subject of the mariner's compass without referring to the great improvements of Lord Kelvin. The improvements relate to every part of the instrument, and I venture to say that none of them could have been made by anyone but a mathematician. In order to get his card steady he knew that its period must be different to any possible period of the waves, or he would have the resonance, to which I have just referred, coming in, so he gave his card a considerable moment of inertia; but this was managed with a light card so that small needles could be used. If the needles are small, the correction by soft-iron masses and by permanent magnets is easier and more accurate. Then the bowl of the compass had to be suitably carried so that it would not be unduly disturbed by shock, and provision had to be made for damping by fluid friction the oscillations of the bowl if they occurred. Lastly, a most beautiful method of correcting the compass, without taking a sight, was discovered. In every detailed improvement one can detect that the inventing mind was that of a most able and trained mathematician.

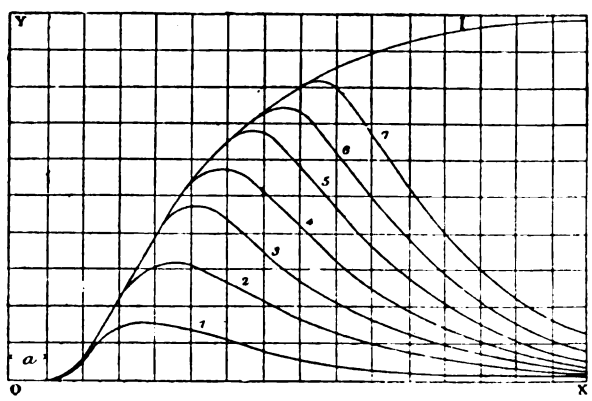

FIG. 5.

An essential of safe navigation is an efficient system of lighthouses. The optical problem of the lighthouse engineer is to construct apparatus which shall usefully direct all the light produced. The present forms of apparatus are in their leading features due to Fresnel, the able mathematician, who established on an absolutely firm foundation the undulatory theory of light. To properly design an optical apparatus formulæ must be used, and the advantage is great if the designer can with ease manufacture the formulæ he requires.

Submarine telegraphy yields some interesting examples of the application of the higher mathematics. When a cable across the Atlantic was first seriously entertained, the first point to be settled was, how many words a minute could be sent through such a cable. This was the most practical question possible. Upon the answer depended the prospect of the cable paying commercially if successfully laid. The matter was dealt with by Prof. Thomson,* of Glasgow, now Lord Kelvin. He showed that the propagation of an electric disturbance in a cable could be expressed by a partial differential equation, and that the solution of this equation under certain conditions applicable to practice could be expressed either by a definite integral or by an infinite series. The values of these were calculated, and hence before an Atlantic cable was laid at all it was known how long it would take a signal to reach the opposite shore, and how much its intensity would be diminished in transmission. Referring to Fig. 5, abscissæ represent time, reckoned from the time of making contact at the sending end of the cable, ordinates the currents at the receiving ends, curve (1) gives these currents when the contact at the receiving end, after being made, is continuously maintained. It will be observed that for a time, a, there is hardly any current at the receiving end, that then the current rapidly increases, and attains to half its final value after a time equal to about $5a$. Curves (1) . . . (7) show the currents at the receiving ends when the contact is made at the sending end maintained for times a, $2a$ . . . . $7a$ respectively, and then broken. Looking at curve (1) one sees how small is the amount of current and how long it lasts compared with the time during which contact is made. The time a depends on the length and character of the cable; it is equal to $k\,c\,l^2 \log_e \frac{4}{3}/\pi^2$, where k is the resistance per unit length, c the capacity per unit length, and l the length of the cable. The knowledge of what is the commercial value of a cable depends on a knowledge of the value of a, and this cannot be obtained without knowing the differential equation $c\,k\,\frac{dv}{dt} = \frac{d^2v}{dx^2}$,* to which I have referred, and its by no means simple solution either as a definite integral or as an infinite series. So far as I know, this piece of higher mathematics cannot be evaded by any mere elementary treatment. The transmission of disturbance in a cable is quite different from the transmission of sound-waves in air, which move with constant velocity. If the cable be doubled in length, it takes four times as long for the signal to pass through it instead of just twice as long, as would be the case if it were a proper wave motion. In fact, the time of passage between the making of contact at the sending end of the cable and the beginning of the resulting disturbance at the receiving end, varies as the square of the length of the cable. The mathematical theory is exactly the same as that of the transmission of heat in a plate, one surface of which is suddenly exposed to a temperature different to the temperature of the plate. This is constantly occurring in the application of mathematics—one piece of mathematical work serves for many physical problems having apparently little in common. Fourier long ago discussed the heat problem, little dreaming that his analysis would be just what was wanted for ascertaining how fast signals could be sent across the Atlantic by a system of telegraphy which in his days had not even been projected in its simplest form. The same differential equation also gives the theory of the transmission of telephonic messages through cables; but the solution is then easier, and tells us exactly why it is so much more difficult to speak through 100 miles of cable than through 1,000 miles of overhead line. As I have just stated, the differential equation of the disturbance in the cable is $c\,k\,\frac{dv}{dt} = \frac{d^2v}{dx^2}$. A musical note of period T spoken into the cable through a telephone is properly represented by $A \sin \frac{2\pi t}{T}$; the disturbance in the cable will be:

$$v = A\, e^{-x\sqrt{k\,c\,\pi/T}} \sin\left(\frac{2\pi t}{T} - x\sqrt{k\,c\,\pi/T}\right);$$

as may be easily verified by differentiating. This equation tells us everything. It tells us the rate at which the waves diminish with the distance. This rate increases with the resistance, with the capacity, and with the frequency. If the capacity is at all considerable, the diminution is rapid. The velocity of the waves is not the same for all frequencies, as is the case with waves in air, but varies as the square root of the period, so that if two notes were sounded the high note would arrive after the low notes, and the resultant effect would be entirely destroyed. Here, again, it is difficult to see how the differential equation and its solution can be evaded.

Though the history of the telegraph dates only from a little more than 50 years ago, it is ancient in comparison with the other great applications of electrical science, which have received their development during the last 15 years. Here, again, mathematics which are not quite elementary have played their part. In the theory of transformers we find another illustration of the need of knowing how formulæ are obtained if they are to be correctly applied. The early transformers were made with unclosed magnetic circuits; there was an iron core, but the lines of magnetic force passed through air for a considerable part of their path. In this case a complete mathematical theory was not very difficult. But speedily-closed magnetic circuits were found to be better, and the relation of magnetic induction and magnetic force became all-important. If anyone were to apply mathematical formulæ which were true for the earlier transformers to the later ones, his results would be inaccurate. Indeed, a wholly different method of attack on the problem was needed, taking account of the facts as they are, and not applying results which were true of older apparatus to cases essentially distinct.†

The employment of alternating currents has brought into use, as a necessity for understanding the actually observed phenomena, a great deal of mathematics. Why is the apparent resistance of a conductor greater for an alternating current than for a direct current? And by resistance I do not mean the quasi-resistance due to self-induction.‡ The mathematical electrical theory is ready with an answer; it is ready, too, to tell us how the difference depends upon the frequency of the current and on the size of the conductor. In the case of a cylindrical conductor the solution involves a knowledge of Bessel's functions. We learn that if the current has a high frequency, or if the conductor be large, there will be very little current in the centre of the cylinder, and that therefore for any practical purpose the centre of the cylinder might just as well not be there; the current is largely confined to the part of the conductor near to its surface. The currents at different depths in the conductor attain to their maximum values at different times; those near the surface of the cylinder occur before those at some distance from the surface. The mathematical conditions are expressed by the same equation as is used to express the disposition of heat in a cylinder the surface of which is submitted to a periodic variation of temperature. Anyone who had

* "Mathematical and Physical Papers," vol. ii., p. 61. Sir W. Thomson.

* v is the potential, t the time, and x the distance from the sending end of the cable.

† *Proceedings* of Royal Society, February 17, 1887.

‡ Lord Rayleigh, *Phil. Mag.*, vol. xxi., p. 381.

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thoroughly mastered the heat problem would be quite prepared to deal with the problem of currents in a conductor. It cannot be too often repeated, any piece of pure mathematics which finds one application to a physical problem is almost sure to find, in exactly the same form, applications to other problems which superficially are absolutely distinct. The differential equation in this case is $k c \frac{d v}{d t} = \left(\frac{d^2 v}{d r^2} + \frac{1}{r}\frac{d v}{d r}\right)$, the similarity of physical condition to the problem of linear propagation of heat is close, but the mathematics differs materially owing to the presence of the term $\frac{1}{r}\frac{d v}{d r}$ in the equation. Mathematics deals with the relation of quantities to each other without troubling as to what the physical meaning of the quantities may be. Hence it is that the mathematical treatment of two such problems as the distribution of currents in a cylindrical conductor and of heat in a cylinder is identical, whereas the treatment of the distribution of heat in a cylinder is quite distinct from the treatment of the distribution of heat in a sphere or in a solid bounded by two parallel planes.

A curious phenomenon was observed in the large alternate-current machines at Deptford when connected to the long cables intended to take the current to London. The pressure at the machines when connected to the conductors was, under certain conditions, actually greater than when not so connected. The phenomenon is one of resonance very analogous to the heavy rolling of ships when the natural period of roll is about the same as the period of the waves.* The period of the alternating current corresponds to the period of the waves, the self-induction of the machine to the moment of inertia of the ship, the reciprocal of the capacity to the stiffness of the ship, and the electrical resistance of the conductors to the frictional resistance to rolling. The mathematics in the two cases is then the same. The effect was predicted long before it was observed in a form calculated to cause trouble.

A problem which is still agitating electrical engineers is that of running more than one alternate-current dynamo machine connected to the same system of mains. Before the matter became one of practical concern, it was considered in this room, and it was shown mathematically that it was possible to run independently-driven alternators in parallel, but impossible to run them in series. That is to say, that if two alternators were connected to the same mains they would tend to adjust themselves in relation to each other so that their currents could be added, but that if an attempt were made to couple them, so that their pressures should be added, they would adjust themselves so that their effects would be opposed.†

Perhaps of all engineering problems which have received their solution in the last hundred years that of the greatest practical importance is the conversion of the energy of heat into the energy of visible mechanical motion. The science of thermodynamics has advanced along with the practical improvement of the steam-engine. By its aid, particularly by the aid of the so-called second law, we know what is possible of attainment by the engineer under given conditions of temperature. I must not trench on the subject of one of my successors, but I may point out that our knowledge of the second law of thermodynamics was first developed by means of mathematics, and that to-day its neatest expression is by means of partial differential coefficients. The two most notable names in connection with the development of the second law of thermodynamics in harmony with the first are those of Kelvin and Clausius; both dealt with the subject in a mathematical form not comprehensible to those who have not had substantial mathematical training.

Illustrations such at these might be multiplied almost indefinitely. They show that the advancement of the science of engineering has been aided in no inconsiderable measure by the labours of mathematicians directly applying the higher mathematical methods to engineering problems. They show, too, one way in which respect for a formula may be dangerous, one way in which it is true that mathematics may be a bad master. In St. Venant's problems we have an example in which the use of older results of limited application in cases where the assumptions on which they rest are not true will mislead. The examples show the proper remedy. It is a more complete application of mathematical methods. The error is just one which a man will make who has the power to use a formula without a ready understanding of how it is arrived at. A practical man, ignoring mathematical results, might or might not escape the error of supposing that a triangular shaft would break at the angles under torsion. The half-educated mathematician would certainly fall into the snare from which complete mathematical knowledge would deliver him. You can only secure the services of that good servant, mathematics, and escape the tyranny of a bad master by thoroughly mastering the branches of mathematics you use. The mistake caused by the wrong application of mathematical formulæ is only to be cured by a more abundant supply of more powerful mathematics.

There is another drawback to the use of results, taken, it may be, out of an engineering pocket-book by those who are not prepared to understand how they are reached and on what foundations they rest. The educational advantage is lost. The close observation which enabled the earlier engineers to proportion their means to the ends to be attained was no doubt very laborious, and the results could not be applied to cases much different from those which had been previously seen, but the effect on the character of the engineer was great. In like manner, to thoroughly understand the theory of an engineering problem makes a man able to understand other problems, and, in addition to this, precisely the same mathematical reasoning applies to many cases. The mere unintelligent use of a formula loses all this; it leaves the mind of the user unimproved, and it gives no help in dealing with questions similar in form though different in substance.

But even the use of mathematics by competent mathematicians is not without drawbacks. Mathematical treatment of any problem is always analytical—analytical, I mean, in this sense that attention is concentrated on certain facts, and other facts are neglected for the moment. For example, in dealing with the thermo-dynamics of a steam-engine, one dismisses from consideration very vital points essential to the successful working of the engine, questions of strength of parts, lubrication, and convenience for repairs. But if an engineer is to succeed, he must not fail to consider every element necessary to success. He must have a practical instinct which will tell him whether the instrument as a whole will succeed. His mind must not be only analytical, or he will be in danger of solving bits of the problems which his work presents, and of falling into fatal mistakes on points which he has omitted to consider, and which the plainest intelligent practical man would avoid almost without knowing it.

Again, the powers of the strongest mathematician being limited, there is a constant temptation to fit the facts to suit the mathematics, and to assume that the conclusions will have greater accuracy than the premises from which they are deduced. This is a trouble one meets with in other applications of mathematics to experimental science. In order to make the subject amenable to treatment, one finds, for example, in the science of magnetism, that it is boldly assumed that the magnetisation of magnetisable material is proportional to the magnetising force, and the ratio has a name given to it and conclusions are drawn from the assumption, but the fact is, no such proportionality exists, and all conclusions resulting from the assumption are so far invalid. Wherever possible, mathematical deductions should be frequently verified by reference to observation or experiment, for the very simple reason that they are only deductions, and the premises from which the deductions are made may be inaccurate or may be incomplete. We must always remember that we cannot get more out of the mathematical mill than we put into it, though we may get it in a form infinitely more useful for our purpose.

Engineers, no doubt, regard their profession from very different points of view: some think it a mere means of making money, some regard it as an instrumentality for benefiting the race, whilst others, again, delight in it as an interest in itself, and delight in it most of all when new knowledge is added to that which we know already. It is just the same with the medical profession: some attend patients for the guineas they receive, some give a very high place to motives of benevolence, whilst others love it as a field where new knowledge may be found and the delight of discovery enjoyed. In regard to the first class of engineers, I have no doubt a little skill in managing a board of directors or impressing a committee of Parliament will be much more useful than a great deal of mathematics. Let him manage his board and buy his mathematician, and it is very probable he will make much more money than the mathematician or any other person of skill whom he may employ. But we cannot all of us make money in this way. In the future it is likely that educated men will have to work harder and receive less, and it is a great thing if their work can be made itself a joy, and surely this can best be by a thorough understanding of the reason of all they do by the feeling that they have full competence to form their own judgments without depending much on the authority of others. This can only be, in the words of Sir John Herschell, by a "sound and sufficient knowledge of mathematics, the great instrument of all exact enquiry, without which no man can ever make such advances in any of the higher departments of science as can entitle him to form an independent opinion on any subject of discussion within their range."

After all, in any department of applied or pure science the highest satisfaction comes from accomplishing that which no one has done before, from disclosing what no one hitherto has shown. If a department of the arts or sciences ceases to advance and becomes simply the application in known ways of known principles to obtain known ends, that department has lost its charm till the time comes for a fresh advent of change and development. To effect such advances it is easy to show that mathematics is a most necessary instrument. Here it is no drawback that the mind of the discoverer is too analytical; he may deal at his pleasure with one aspect of a problem, and it does not detract in any way from the value of his solution that he does not touch on incidental matters. Some of you who love the interest of continual advance in our science and practice, may look forward with a shade of sadness to a possible time when all is done or known which can be done or known, and the work of the engineer shall be merely applying principles discovered by his predecessors. In such a state, when the experience of the older generations shall control the practice of to-day, the free use of mathematical methods may be effectually superseded by the application according to rule of mathematical formulæ. But it would be a much less interesting condition than the constant change of to-day, when the practical experience of 10 years ago is in many departments rendered worthless by later discoveries. But we need not fear that such a time of petrifaction will come so long as, whilst reverencing the discoverers who have added to our knowledge, we endeavour to replace their methods by better, and expect that those who come after us will, in their time, improve upon ours. Our knowledge must always be limited, but the knowable is limitless. The greater the sphere of our knowledge the greater the surface of contact with our infinite ignorance.

* Institution of Electrical Engineers, November 13, 1884.

† *Minutes of Proceedings*, Institution Civil Engineers, April 5, 1883; Institution of Electrical Engineers, November 13, 1884.

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THE
ELECTRICAL ENGINEER.

Published every Friday.
Price Threepence; Post Free, Threepence Halfpenny.
Editorial and Publishing Offices:
139-140, SALISBURY COURT, FLEET STREET,
LONDON, E.C.

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PROF. KENNEDY AND CHEAP CRITICISM.

We are somewhat interested in the statement made in the presidential address to the Mechanical Engineers to the effect that "it is a favourite bit of cheap criticism indulged in by those who have not to supply energy on a large scale at the expense of those who have; that the former class of folk show their ignorance of their own work and interests by neglecting to obtain that enormous demand for motive power which would come on them if they only reduced their prices low enough." The whole paragraph containing this sentence is to the same effect. Now we have indulged in a good deal of this cheap criticism, but we do not think that Prof. Kennedy translates our arguments justly, nor, indeed, do we know if he had any of our remarks in mind when writing his sentences. It is certainly very much due to the aid of this species of cheap criticism that the public mind is enlightened upon any point. Very often, indeed, the criticism may be crude, may even be incorrect, but the crudities will be toned down as knowledge increases, and the incorrectness can be corrected by those who know better. A wholesale condemnation of criticism fails in its object. We are not all-infallible—we do not pretend to be—but we do pretend to have given some slight attention during the past twenty years to the matter of electrical development; and our own conclusion is that in very many instances consulting engineers have failed to provide in their schemes for possible developments. Surely Prof. Kennedy would not have us "rest and be thankful" with the distribution of electric energy for lighting purposes. Electric lighting came first as a luxury—it will end by being a necessity; and we think electric lighting never had the arguments in its favour which can be put forward in many cases for the use of electric energy for power purposes. No one who has considered the subject has, so far as we know, suggested that distribution for power purposes would be immediately successful commercially in all districts. That would be absurd, but even Prof. Kennedy admits there are selected districts where a considerable amount of power might be furnished if the cost was sufficiently low.

We have very strong opinions as to the duties of technical journals. In the first place, they must be convinced that the development suggested is possible, and on that score, so far as the distribution of electric energy is concerned for either light or power purposes, we are agreed. Secondly, they have to determine roughly whether the suggestion, if carried into practice, will result in economy (1) generally or (2) only in special cases. On this latter point agreement is pretty universal. We have ourselves more than once instanced the district around Fleet-street, wherein there are hundreds of small steam-engines—say from 2½ h.p. to 10 h.p. nominal—wherein, too, other hundreds have been replaced by gas-engines. This type of steam-engine, especially worked, as many of these are worked, very intermittently and far from fully loaded, cannot be said to be economical. Again, the space occupied by the engine and boiler is valuable, and can be better utilised by erecting thereon another machine. But so far as this

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district is concerned, it seems we are all agreed. Our investigations tend to show that in almost every large town there are numbers of users of such uneconomical combinations that, no matter if the electrical energy were supplied at lighting terms, it would be better to use it than the old ramshackle steam-engine now in use. The reference of Prof. Kennedy to gas companies is particularly unfortunate. These companies are straining every nerve to get gas introduced for heating purposes, and we have very little doubt but that a different rate might have been in the first place obtained by users of gas for power or heating purposes had there been any prospects of keen competition from any other source.

There is no demand even in Fleet-street for electrical energy for power purposes, because we all know it cannot be had, and business men don't cry for the moon, if children do. The same may be said of Mayfair, but there the argument is different. The power there would be more in the shape of a luxury, and we are not sure that motors for lifts, or for boot and knife cleaning, are silent enough for these aristocratic mansions. We do not think, in fact, the time has yet come to say the distribution of electrical energy for power purposes is as advocatable—to coin a word—in purely residential as in some business quarters. Lastly, we should advocate in many instances electrical energy for power purposes on the score of expediency.

After all, we do not think Prof. Kennedy will differ largely from us. There is no necessity to chop logic as to whether the demand must first be created, or the supply be in readiness. Nor is it necessary to do more than refer to large factories. The power they use is far more economically obtained than that of small users. We believe that under many conditions the supply of electric energy is possible and is economical, that such supply would be advantageous to central-station work, and that the demand for it should be fostered.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

THE VARLEY TESTIMONIAL.

SIR,—I would ask to be allowed, through the medium of your columns, to express my deep obligation to the members of the testimonial committee for having so gracefully recognised my services to applied science in the circular they issued shortly after the formation of the committee. I would also ask to be permitted to return my sincere thanks to all those who have subscribed to the testimonial fund.

My thanks are I feel in a special sense due to Lord Kelvin for so kindly accepting the post of chairman, and for taking an active part as leading member of the committee. I wish also to express my deep obligation to the three executive members on whom the work has chiefly fallen—viz., Mr. Crompton (the hon. sec.), Mr. Gatehouse, and Mr. Stroh (the treasurer).

And now that the testimonial fund has been brought to a close, I find it difficult to realise that nearly nine years have elapsed since I was first looked up on behalf of leading firms who refused to recognise the claims asserted by the Anglo-Brush Corporation.

At that date, for reasons which came out in evidence in the law courts, I was reluctant to take the initiative in asserting my claims as the inventor of compound winding, but when my anticipation of the Brush patent had been brought forward publicly in the interests of the dynamo industry I considered that I owed it as a duty to myself, as well as to the trade, to establish the priority of my invention, and from that time I regarded the matter as a duel between Brush and myself, and a battle with the scientific experts who were assisting the Anglo-Brush Corporation.

In the beginning of December, 1887, to my very great regret, the firms in whose interest I had been originally looked up, retired from the defence, and a compromise altogether in the favour of the Brush Corporation was arranged.

An article recently published in the *Pall Mall Gazette*, headed "At a Vigintave," throws a side light on how it came about that wealthy English firms should have given way without fighting a battle. In the article I am referring to Colonel Gouraud is reported to have said, "I am a firm believer in litigation as the only test of a patent's merit. Look at the telephone, now. The very first thing I did when I got a wire from Edison to say that he had invented a telephone and wanted me to take it up, before I had even seen the instrument, was to go off and retain the three best patent counsel in the kingdom. The result is that we have never lost a case."

Now, the Anglo-Brush Corporation acted on similar tactics to those of Colonel Gouraud; they retained Sir Richard Webster, Moulton, and other of our ablest counsel, as their legal advisers, and as scientific experts they retained Sir William Thomson (Lord Kelvin), Sir Frederick Bramwell, Messrs. Latimer Clark and W. H. Preece, Profs. Perry, Silvanus Thompson, etc.

It is a matter of history that all the more important electrical cases previous to that of Brush *v.* Crompton, with the single exception of Wilde *v.* Gramme, had been mainly won by the ability of counsel, the official status, and the clever special pleading of scientific experts; and that being so, the defendants in the case of Brush *v.* Crompton, although they had no manner of doubt as to the soundness of the defence, considered themselves to have been strategically outmanœuvred, and under the circumstances they came reluctantly to the conclusion that discretion was the better part of valour.

So soon as I was advised that a compromise had been arranged, I determined to try and get the case reopened, and in a series of articles published in the *Electrical Review* I discussed the respective claims of Varley and Brush to be considered the first to have described a system of compound winding.

In the course of my articles I expressed the opinion that the trade had allowed the Anglo-Brush Corporation to simply walk over the course, and that it seemed to me they had acted very shortsightedly in doing so. I stated it required no prescience to foresee that the next step on the part of the Brush Corporation would be to apply for a prolongation of their patent, and, I added, who shall blame them, seeing that under the circumstances they would probably be successful? I also directed attention to the fact that the previous attempt of the proprietors of the Wilde patents to obtain a monopoly of the dynamo industry had been successfully resisted,* and referring to what I would now term "Gouraud tactics," I said a feeling had been growing upon me for some time that there was need for a new strategy, that it was seldom sufficient to act solely upon the defensive, decisive victories being obtained were often than not by flank marches, and attacking the base of operations. I then proceeded to

* In the lawsuit of Wilde *v.* Gramme, the proprietors of the Gramme patents, who were foreigners, finding themselves involved in very considerable expenditure, resolved to withdraw from the defence. I regarded their doing so as little short of a catastrophe, as I foresaw it would probably result in the formation of a wealthy syndicate, and the making the dynamo industry a close monopoly. Under these circumstances I offered my professional services on the side of the defence gratuitously, and I had the unique advantage of being the sole scientific adviser. Wilde was successfully resisted, the battle being practically won at the disclaiming stage, as leave to disclaim was refused, and when the case was called in court it was allowed to go by default, Wilde paying costs.

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analyse the affidavits sworn to on behalf of the Anglo-Brush Corporation, and after showing how weak they really were, I said if the trade would rally round me I would make it a life and death struggle, and take the matter up with a determination to win.

The outcome of my articles was that Messrs. King, Brown, and Co., of Edinburgh, decided to oppose the Anglo-Brush Corporation, and I was given a verbal assurance that they would carry the case through the Scottish courts, and, assuming they were successful if the case were taken to the House of Lords, they would fight it there.

Instead of waiting to be attacked, Messrs. King, Brown, and Co. assumed the offensive, and as English counsel cannot plead in Scotland, this strategy checkmated the "Gouraud tactics," for it broke up that organisation of able barristers and scientific experts who had won electrical case after electrical case in the English courts, and, as a consequence, the battle was fought out on less unequal terms than it otherwise would have been.

When the time for hearing the case for the reduction of the Brush patent was drawing near, the Anglo-Brush Corporation tried to arrange a compromise, and they offered terms favourable enough for the legal advisers of Messrs. King, Brown, and Co. to advise their clients to accept. I energetically opposed any compromise being come to, and the raising a guarantee fund was offered me as the alternative. I at once issued a pamphlet to the trade, and brought my personal influence to bear also; a guarantee fund was raised, and the respective claims of Varley and Brush to be considered the inventors of "compound winding" were fought out in the Court of Session, Edinburgh, in November, 1888. Some months later judgment was given altogether in favour of Varley, and on appeal this judgment was not only sustained, but strengthened.

The immediate effect of the second judgment delivered in the Scotch Courts was that the Anglo-Brush Corporation found it necessary to liquidate and to reconstitute themselves as a new company. The case was, however, carried to the House of Lords, and, as is well known, the Lords delivered judgment on April 4, 1892, and, without hearing counsel on behalf of King, Brown, and Co., they declared Varley to be the inventor of compound winding.

The part I have been permitted to play in respect to the dynamo, it must be admitted, is unique. The discovery of what Lord Kelvin has aptly named the dynamo principle is admittedly one of the greatest discoveries of the century. I was the first to discover this principle, and the original dynamo, constructed in August, 1866, and provisionally protected in December of the same year—the first machine made of the type of dynamo now in use—and for the designing of which I was awarded the gold medal of the Inventions Exhibition of 1885, is at the Patent Museum, South Kensington. I am also the inventor of the second great advance in dynamo construction—viz., compound winding. My claims to this invention have been thoroughly sifted by the highest courts in Scotland and the United Kingdom, and, although opposed by a most powerful financial corporation, assisted by the highest legal and the scientific talent, whatever claims I have urged as the first inventor, have been fully sustained in each of the three judgments delivered.

I have the satisfaction of feeling that in the course of my life it has fallen to me to make advances both telegraphically and electrodynamically; I have the satisfaction of feeling also that I have been the means of rescuing the industry from being made in no small degree a monopoly.

I might be forgiven, I think, were I to take credit for having invented a legal strategy which enabled me to successfully deal with an organisation having its origin in the Government telegraph monopoly, but which had been developed by powerful financial corporations into what seemed to be an all-powerful machine for crushing out private enterprise; but if I take credit to myself for pioneering a new strategy, I do not overlook the fact that it would have been of no avail but for the public spirit of a Scotch firm, who took upon themselves the responsibility and incurred considerable expenditure in fighting what was really the trade's battle, rather than their own.

The pecuniary gain to the industry which has resulted from reopening the case after the trade had given way, must have been very great. To myself the period now being brought to a close has been one of labour and great mental anxiety, for I have felt all along the heavy responsibility I undertook when I urged the trade in 1887 to rally round me and resist. I took up the case, as I promised, with the determination to win; and in carrying it through to success I have given my time, in no small degree, gratuitously.

A list of the names of those who have subscribed has been given me, and I am very pleased to find among the subscribers the names of men of the highest distinction in physics, in electrical engineering, and electric pioneering, and the legal profession, but at the same time I confess it is depressing to me to find that, with the exception of a few of the more distinguished members of the dynamo industry, the manufacturers who, as a whole, must have largely benefited from my successful efforts to overthrow monopoly, should not have responded to the invitation of the committee.

I feel very much indebted to the committee, and therefore I hope I shall not be misunderstood when I say I am sorry it has been found necessary to protract their proceedings over so long a period; memories are short in these days of high pressure, and when one has arrived at the wrong side of sixty, two years is a considerable portion of his life.

I am pleased to be informed that Lord Kelvin is exerting his exceptionally powerful personal influence to carry successfully through a resolution passed at one of the meetings of the committee. It is very important to me that his efforts should be crowned with success. The matter, I am sure, could not be in better hands, and I shall always feel that Lord Kelvin has placed me under a special obligation.—Yours, etc.,

S. ALFRED VARLEY.

53 and 54, Chancery-lane, W.C., April 28, 1894.

DECIMAL NOMENCLATURE.

SIR,—Everybody will thank Mr. Hayward for his communication in last week's issue. His suggestions are at once original, ingenious, and linguistic in the highest degree. The new system, if introduced into our schools, would, we may be sure, do more to stimulate the critical faculties as well as the power of memory, patience, and elocution than whole volumes of verses. There has hardly been so refreshing a novelty presented to the engineering world—never too gay—since the happy day when we began to "squirm" up and down stream in electric launches. But this beautiful and expressive verb sinks into insignificance by the side of Mr. Hayward's elastic piece of mechanism, which dekens and dekets away, without any hitch, to an indefinite extent in either direction. The examples that he gives should be convincing as they stand; but the following specimen of a calculation may help to dispel any remaining doubts as to the merits of the system.

Example (taken from Prof. Ayrton's "Practical Electricity," page 327).—Find the work required to separate the plates of a given condenser, the necessary data being given.

Capacity before separation equals (2 dideks 8 deks and 8 over 4 and 4 dekets 5 didekets 2 tridekets by one-third of a deket) dodecafaradets, or 1 and 9 dekets 4 didekets of an enfaradet.

After separation it becomes 6 and 4 dekets 6 didekets 7 tridekets of an octafaradet. Hence if K = charge, and V the P.D. after separation,

K = 1 and 9 dekets 4 didekets by an ennadeket by 2 dideks 5 deks;

= 6 and 4 dekets 6 didekets 7 tridekets by V, whence V = 7·5 divolten.

The store of energy before separation = (1 and 9 dekets 4 didekets by 2 dideks 5 deks squared over 2 and 7 dekets 1 deket 2 tridekets) enna foot-poundets; and

After separation (1 and 3 dekets 4 didekets 1 trideket) tetra foot-poundets, from which it is obvious at a glance

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that work done in separation = (8 and 9 dekets 3 didekets 9 tridekets) penta foot-poundets.—Yours, etc.,

TRIAMPERET ALIAS MILLIAMPERES.

Thames Ditton, May 2, 1894.

ELECTRIC TRACTION IN RAILWAY TUNNELS.

BY FRANK B. LEA.

There are short railway tunnels and there are long ones. It is, of course, with the latter that we have to deal, for the special benefits of electric traction as compared with the use of steam locomotives can only then be said to come into play when considered in regard mainly to the important matter of ventilation.

The object of tunnelling—the reason for the existence of these magnified rabbit holes—is either to avoid the expense of surface wayleaves over enormously valuable land—as, for instance, in the case of the underground railways which are becoming such a marked feature of transit systems generally in London and other large towns—or else to penetrate a hill, and thereby also avoid great expense in working a line with excessive gradients otherwise rendered necessary. In the first class of long tunnels there is obviously no superior rival to electric traction, as appears evident from results on the City and South London Railway, and also from the plans set forth for lines situated similarly. With all due deference to the wisdom and experience of those in authority over the Metropolitan, the District, and the Mersey Tunnel lines, etc., it may be doubted whether any steam-operated railway underground can achieve reasonable success, for in proportion as the atmosphere generally of a *soi disant* civilised country becomes more and more carboniferous, its inhabitants will be forced to take every opportunity of amending in detail the conditions of life. If the production of smoke and sulphur is essential in certain directions, the number of instances where this is not the case will be reduced as much as possible.

It is, however, with reference to the second type of railway tunnels that these remarks are more especially written, since there is, even at the present time, a much larger scope than would be imagined for the use of electric traction in this way. Quite recently, for instance, a leading daily newspaper published some details of the excessive inconvenience, if nothing more, which is apparently a matter of everyday life with the railway officials engaged on the St. Gothard and Mont Cenis routes. In passing through the long tunnels, engine-drivers, stokers, and guards have more than once been almost wholly overcome by the foul air, which under certain conditions cannot very readily be dispersed even with the usual ventilating appliances; and the same thing will be found on other lines in mountainous districts where tunnels are both numerous and long. This very fact, however, points at once to the remedy, for if electric traction were introduced on the hilly sections of these lines, it would not only be in most cases quite possible, but also much more economical to employ adjacent water powers as the prime source of tractive energy instead of using poor and expensive qualities of foreign coal or artificial fuel, in the shape of briquettes, for the purpose of raising steam in the locomotives, whose smoke is so offensive and troublesome, and whose efficiency is not so great in proportion as that of their electrical counterparts.

In many cases, it may be objected, the heavy weight of a steam locomotive is actually required for adhesion purposes on such lines, where steep gradients are almost always prevalent; but here, again, the remedy is obvious. A good system of rack railway like, for instance, that invented by Mr. Abt, and now so extensively coming into use on main lines as well as branches, would provide ample means for climbing heavy inclines with the light motors required in electric railway work. In this way, a still further gain in the operating expenses may be effected, for there are very few steep grades which do not necessitate the use of two locomotives even with ordinary trains. An electric rack locomotive will, however, pull a far greater train load—in proportion to its dead weight—than could ever be hauled by steam adhesion locomotives of equal power. Upon a gradient, for instance, of 1 in 25—by no means an uncommon or excessive incline, even upon main-line railways running through a mountainous country—the weight of steam locomotive necessary for adhesion purposes in propelling a train of 125 tons weight would be at least 50 tons; and even this train load would be too much whenever the rails should happen to be greasy. There is under such circumstances, therefore, a dead weight in the locomotive of at least 10 tons for every 25 tons of train weight. An electric rack locomotive, *per contra*, will not weigh more than about 25 tons for the same tractive force, yet by its use the train weight could be increased to 150 tons, or a proportion of 10 tons dead weight in the locomotive to 60 tons of train weight.

Of course, some amount of engine weight is necessary even in the rack system, but it may be materially reduced in this way far more than is possible with adhesion locomotives. To put the matter briefly, the ratio of tractive force to engine weight in adhesion systems can rarely be allowed to exceed 1 in 5: more usually it is less. With a rack, however, like that devised by Abt, the ratio is nearly reversed, for the engine weight needs only to be about one-quarter of the tractive force to overcome the tendency of the rack pinions to climb out of gear.

Emphasis has been herein laid on this point to show how easy it is to cope with *all* the difficulties inherent to mountain lines where long tunnels are numerous, and entail great inconvenience both to passengers and train staff. The use of heavy steam locomotives, two or even three to a train in ascending steep grades, with their strong tendency to smoke when fully loaded and fed with poor fuel, is not in any way essential to the proper conduct even of a main-line service. The rack locomotives need not be confined to such short parts or sections of the line as appear to require the use of a rack: they may be so constructed as also to work by adhesion upon the less hilly portions. Indeed, they can with advantage be worked upon the entire mountain section—say, for instance, in crossing the Alps or any other great range—where water power is usually available in a cheap and easily-applied form for the generation of electric energy at fixed points, whence it may be carried in the ordinary way along the line.

On the score of improved ventilation, there are evidently, then, strong reasons for adopting electric locomotives upon such lines: it might doubtless be possible to erect blowing engines or huge fans for creating a powerful current of air through long tunnels, but the same expenditure on plant would almost cover the cost of a complete electric equipment, whilst obviously the total working expenses would be higher in the former case than when steam is abolished altogether. More might be said in this connection with regard to the much greater safety and ease of control afforded by the rack system when descending steep grades, but this feature, although important, hardly concerns the question of long tunnels and how to work them. The chief advantage remains, that the air within a tunnel may, by the use of electric traction, be kept as pure and healthy as that outside; whilst, as, of course, quite a minor item of information, railway managers may be pleased to hear that the cost of working the line would in nine out of ten such cases be materially reduced. Any other conclusion it would be impossible to reach when we are, for instance, told that the cost of fuel on the Canadian Pacific—a typical railway of the kind—is as much as 11d. per locomotive mile.

THE TRANSMISSION OF ELECTRICAL ENERGY BY HIGH-TENSION SERIES DYNAMOS.

Herr Ernst Schultz, of Aix-la-Chapelle, in an article in the *Elektrotechnische Zeitschrift* on the transmission of electrical energy by means of high-tension direct current by means of series dynamos, says that under certain circumstances the employment of series machines offers advantages over the employment of compound dynamos and shunt electromotors. In recognition of this fact, the Deutsche Elektricitätswerke of Aix-la-

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Chapelle, in power transmission plants where there is only one motor at the secondary station, have employed series machines, and the practical results have accorded with the theory.

One of the installations in question is that of Herr Cuno Kammandel, at Geisa, in Thuringia. The little town of Geisa has running through it a stream, the Ulster, which has a heavy fall. Below the town there is a mill-race, which used to be utilised for driving a flour-mill. On a hill directly opposite the mill-race is situated the cork factory of Herr Cuno Kammandel. Formerly steam power was used here to the extent of 20 h.p. Owing to coal having to be carried by carts a distance of three miles the cost of fuel was doubled, and it was consequently decided to employ electric transmission of power from the Ulster. The water power available is employed to drive a turbine made by Messrs. Briegleb, Hansen, and Co., of Gotha. The regulation of the revolutions of the turbine is effected by hand. From the vertical shaft of the turbine horizontal gearing is driven, which actuates by means of pulleys and belts the primary dynamo, which at 700 revolutions per minute has an output of 650 volts and 32 amperes. At full load the dynamo requires 32 h.p. The dynamo is series wound of the four-pole type, and delivers current to a switchboard, where, in addition to a double-pole main switch, there are an ammeter, a rheostat with 16 contact-pieces, and an automatic short-circuiting switch. The rheostat, which is inserted parallel with the field-magnet winding, permits of the strengthening or weakening of the field of the generator, and so controls the number of revolutions of the electromotor, which receives current at more or less pressure. The automatic short-circuiter is a safety apparatus which, in the event of the primary machine being overloaded, short-circuits it. The current is led to the secondary station by copper wire of five millimetres diameter, the wire being supported on 15 telegraph posts. The distance is about 2,200ft. Porcelain insulators of the telephone type are used. Each conductor is protected at both ends by lightning conductors. The leads pass in their course over a governmental telegraph line, and are carried 3ft. above the same. The electromotor at 650 revolutions per minute yields about 600 volts and 24 h.p., and this is the sole motor in the factory. It operates by means of a belt on the main shaft, which works the various machines required, and also the pumps which supply water to the works from the mill-race. The installation has, with a loss on the conductors of 50 volts, a total efficiency of 75 per cent. from the shaft of the dynamo to that of the motor.

Another installation is to be found at the dyeworks of Herr Louis Hermsdorf, at Chemnitz. Instead of using the water from the town supply for the requirements of the works, it is drawn from the River Chemnitz, a rotary pump being employed for the purpose. This is driven at 1,000 revolutions by an electromotor of 10 h.p. The generator is situated at a branch works 1,000ft. distant; at 1,000 revolutions per minute it yields 30 amperes and 300 volts, and is of 14 h.p. This dynamo is driven by steam power. The arrangements are the same as in the Geisa installation. The conductors employed are four millimetres in diameter, and are supported by eight posts.

A third installation has been carried out at the dyeworks of Herr Oswald Sattler, at Meerane, Saxony. The object of the installation is to supply the works with water. The distance the water has to be brought is about 4,700ft., and 3 h.p. is required for the purpose. The primary machine is driven from a steam engine. It is a two-pole dynamo, giving 300 volts and 11 amperes and 5½ h.p. at 1,275 revolutions per minute. The conductors are carried through the streets over the telephone conductors. Insulated copper wire is used at the crossing points. The conductors elsewhere are bare copper wire, and are carried on 33 wooden posts. The electromotor yields 270 volts and 3 h.p. at 1,400 revolutions per minute. The installation has worked satisfactorily for five hours per day since it was put up.

A fourth series transmission plant is to be found at the Saxon Brassworks at Rodewisch. At the primary station there is a turbine of 55 h.p., which drives by belt a four-pole series dynamo of 500 volts and 70 amperes and 53 h.p. at 600 revolutions per minute. The conductors are carried on double-bell insulators on 40ft. poles—the diameter of the wire being 10mm. The poles are about 200ft. apart. At the rolling-works there is a series electromotor of 450 volts and 41 h.p. running at 600 revolutions per minute.

THE USE OF SMALL ARC LAMPS.

The question of introducing small arc lamps is being discussed in the columns of the New York *Electrical Engineer*, with special reference to an editorial published in that journal on March 14. Mr. W. S. Barstow says that he has not settled in his own mind whether arc lamps will be introduced from 50 c.p. upwards, and that a lamp requiring 125 watts has proved itself in Brooklyn a somewhat doubtful success due to the cost of trimming. Arc lamps of 200 watts are, however, a commercial success in that town.

Prof. Elihu Thomson, writing in the same journal says: The application of arc lamps on constant-potential circuits, such as are used for incandescent lighting, naturally raises the question whether quite small arcs or arcs of very limited candle-power may not become available at some time in the near future. As far back as 1882 and 1883 the writer experimented with arcs using as low as two to three amperes, and with a potential between the carbons of about 50 volts. An arc with 2½ to three amperes was readily obtained, and the mechanism for feeding accurately the carbon of small diameter was worked out, but the great difficulty at that time was that no carbons could be had pure enough or uniform enough in structure to permit such arcs to be run steadily, and the feeding mechanism was naturally more delicate and costly than that used with larger carbons, while the length of lamp to accommodate such lengths of carbon as would provide for an eight hours' run was so considerable as to render the lamp ill-proportioned. Subsequently there was tried enclosing the carbons, made of short plates, in a chamber of glass with limited air supply or none at all. This gave better results, but the carbons gave out enough impurities to obscure the glass in a moderate time. With very pure carbon the results might have been much better. The actual waste of the carbon was very slow, and with a good arc length the light was quite steady. The great economy of light production in the arc is sufficient of a stimulus to make such efforts to obtain small arcs of reasonably low candle-power, worth the making. Such experiments were convincing as to the need of very pure carbons, a supply of which was not to be obtained. This need still exists, so far as the writer is aware.

Very small arcs, when burned in the air with ordinary carbons, have a woeful tendency to rotation, a motion of the arc which has a very disagreeable effect on the character of the lighting, and practically destroys its utility. The rotation seemed to be regularly performed by the arc in the crater of the positive carbon, casting the main body of light in a rotary manner, or a constantly-changing direction. With a good quality of carbons, arcs using from 160 to 200 watts are perfectly practicable even with the ordinary mechanism for feeding the carbons. It is gratifying to discover a growing appreciation by station-men and others of the fact that the best results in arc lighting are dependent on the use of the finer varieties of carbon instead of the less perfect, though cheap, carbons so commonly employed. Even the low-price carbons of to-day are, however, in quality very far ahead of the only available carbons of the pioneer days, for which a good round price had to be paid. In fact, really fair carbons were a rarity in the years between 1879 and 1883, and many a plant was subject to condemnation when everything was right except the carbons available for use with it. In fact, those who enter arc work to-day can never obtain an appreciation of the difficulties which were encountered and had to be overcome in making the arc light a commercial success. There was, of course, an added prejudice against the light itself because it was a white light, or appeared bluish in relation to flames, torches, and such other "hereditary" night lights. It is easy to account

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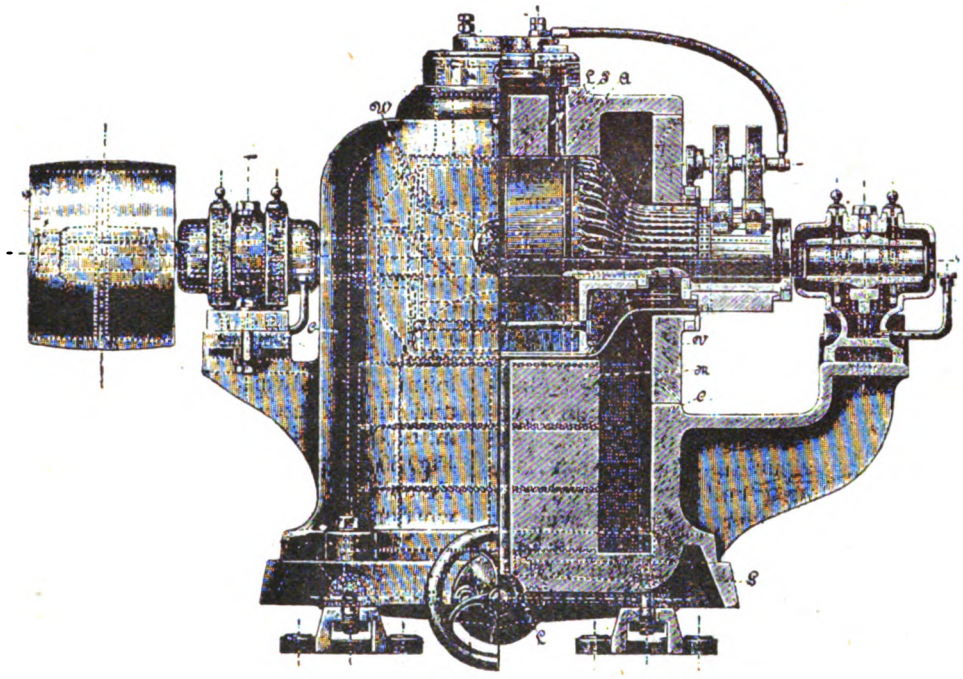
for such prejudice, and it is difficult to see how it could have been avoided. For countless ages the human race had relied for night light on fires, torches, lamps burning fats or oils—and the sensorium had come to expect a night light to be orange or yellowish in quality, and to be able to recognise no other to be in correspondence with hereditary expectation. Hence the sudden appearance of a white light at night was a sort of shock which could only be assimilated in the consciousness as something uncanny, inspiring dread or distaste rather than the reverse sentiment. It was called a ghostly light or a ghastly one, and its unsteady flashes and flickers recalled the terrors of the thunderstorm in the night with its bluish and blinding sheets. Burning in full daylight, arc lights have really a yellowish aspect, showing a large proportion of such rays to be present in the arc.

It does not appear that the introduction of small arcs should have any serious effect on the use of incandescents in their legitimate field. It ought, indeed, to have in many instances an opposite effect in somewhat the same way that the introduction of arc lights often led to increased gas consumption, as the standard of sufficiency in illuminating created a demand for more light. When the incandescent lamp was first brought out, predictions were heard that arc lighting would soon become substantially a thing of the past. The writer never felt that any such predictions were likely to be verified, and continued to work assiduously in the arc lighting field, believing thoroughly in its permanence. We may, perhaps, feel equally assured that even if arc lamps of as low power as 50 c.p. became a commercial reality there would still remain a vast field for the extension of lighting by incandescent lamps.

NEW TYPE OF DYNAMO.

A new type of dynamo, which has been designed by Messrs. Pöschmann and Co., of Dresden, is described by Mr. Thom. Marcher in a recent issue of the *Elektrotechnische Zeitschrift*. The illustration shows the principal parts of the dynamo. A round massive magnet core, M, with its coil, is arranged in the centre of a circular bed-plate, G; opposite to this is an upper pole-piece, P, and both are united by means of a closed vertical undivided cylinder, C, closed at the top and bottom. The latter has against the commutator side an opening, which, after the armature, A, has been put into position, is closed by a cover-plate, V. By this arrangement the magnetic distribution is confined to a minimum, sparking is almost entirely avoided, and the amount of copper used is comparatively small. In consequence of the air resistance between the armature and magnet, the magnetic distribution is not entirely removed, as the surrounding air forms a parallel conductor. A small number of lines of force will therefore pass into the air-space and be enclosed by means of the air and the casing without entering the upper pole-piece. There will consequently be a difference in the number of lines of force in the upper and lower poles, which would partly cause downward pressure of the shaft. In order to overcome this, a collar, W, is placed round the upper pole to suck up the lines distributed, and this is suspended in the neutral position. Tests have shown that by this means the armature swings quite free, especially if the shaft is carried in bearings only a fraction of a millimetre out of centre in an upward direction. The machine runs in ball bearings, with double ring lubrication. Ventilation holes, L, are provided in the centre of the magnet core. The air, which is drawn through by means of these and the belt pulley, plays round the armature and passes away from the casing through lateral perforations. It may be mentioned that Prof. Puluj, of Prague, has tested a dynamo of this type capable of energising 200 lamps. The efficiency of the machine at half load was found by the professor to be 91½ per cent., or at full load 93 per cent.



INSTITUTION OF MECHANICAL ENGINEERS.

ADDRESS BY THE PRESIDENT, PROF. ALEXANDER B. W. KENNEDY, LL.D., F.R.S.

(Concluded from page 503.)

I have spoken of possible breakdown of engines or dynamos. There are, of course, other accidents to be provided against. Short of a boiler explosion the most serious of such accidents would doubtless be one occurring to a steam-pipe. The physical consequences of the actual bursting of a steam-pipe are not, of course, the matters at present under consideration. In all probability such an accident would disorganise any station, no matter how well arranged. But short of the actual bursting of a pipe many things happen which may render it necessary to shut down a portion of piping It is generally necessary, therefore, to provide any lighting station with something in the nature of a ring-main system, or its equivalent, by which any engine in the station can be supplied with steam from two directions. In a properly arranged ring-main system it should be possible to disconnect or cut out of use any section of steam-pipe which may be giving trouble without stopping a single engine. Of course, it is not necessary to provide pipes so large that under these conditions there should only be the normal drop of pressure between boilers and engines. One can put up with an extra drop without grumbling if it only occurs under these circumstances. It is inevitable, to reach the required degree of security in this matter, that the steam-pipe should be fitted with a very large number of valves, and these are undoubtedly objectionable if only on account of the very considerable loss by radiation which is almost inevitable from their covers and flanges. But, after all, the making of good steam joints in large pipes at 150lb. pressure is nowadays a very simple matter, and

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the unavoidable complexity of the arrangement is more than counterbalanced by its usefulness. The duplication of the steam-pipes must obviously extend to the boilers as well as to the engines. The hanging up of a safety-valve, the blowing of a mudhole joint, the bursting of a tube, or any one of half a-dozen other such accidents, may put a boiler suddenly *hors de combat*. It must be possible, therefore, at the shortest notice to cut out any boiler without interfering with the working of the rest. Fortunately, boilers can be forced more readily than engines or dynamos, and such an accident could almost always be met by forcing the remaining boilers somewhat. Reserve in boilers stands thus in the same position as reserve in machines, except in so far that the boilers can be more easily forced, as I have just pointed out. With them, however, as regards security of working, there comes in an even more difficult question than that of reserve—namely, that of readiness for emergencies other than breakdowns. Even in London, where a fog may cause the load on a station to increase ten times in as many minutes, there is

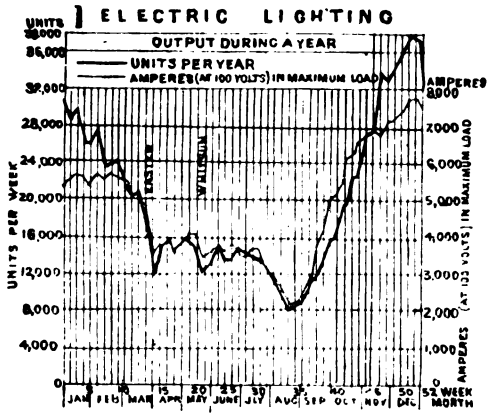
1 ELECTRIC LIGHTING
OUTPUT DURING A YEAR
UNITS PER YEAR
AMPERES (AT 100 VOLTS) IN MAXIMUM LOAD
UNITS PER WEEK
AMPERES (AT 100 VOLTS) IN MAXIMUM LOAD
AMPERES
WESTER
WHITSUN
JAN FEB MAR APR MAY JUNE JLY AUG SEP OCT NOV DEC 52 WEEK MONTH

DIAGRAM 1.—This diagram corresponds to the output at the Davies-street Station of the Westminster Electric Supply Corporation during 1893. The great excess in the last quarter over the first quarter is to a considerable extent due to the larger number of lamps which were on circuit towards the end than at the beginning of the year. The great drop in the last week of all is due to the fact that that week included Christmas Day and Boxing Day, as well as a Saturday and Sunday.

practically no difficulty in getting the engines started quickly enough. It is otherwise with the boilers, which, although so easily forced when actually in work, are terribly sluggish in getting up steam as compared with the rapidity with which unexpected darkness used to come over London, and doubtless will come over again when the sun has recovered from its present attempt to outshine all artificial lights. At the most inconvenient time for a breakdown—namely, the time of full load—the engineer knows at least that an engine or dynamo accident can hardly affect him to more than 15 or 20 per cent. of his whole work, of which at the worst a considerable portion can in most cases be taken up by the remaining plant. But the most inconvenient time for a fog to come on is at light load, and then the increase coming

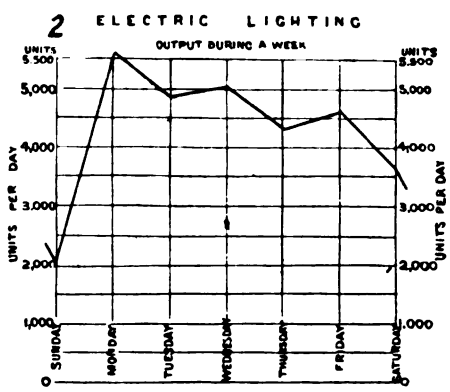
2 ELECTRIC LIGHTING
OUTPUT DURING A WEEK
UNITS PER DAY
UNITS PER DAY
SUNDAY MONDAY TUESDAY WEDNESDAY THURSDAY FRIDAY SATURDAY

DIAGRAM 2.

on in a few minutes may be anything from 500 to 1,000 per cent.! And the engineer must be able to meet this in June as much as in December, and with even less notice. Practically, this means that even in summer enough boilers must be kept under steam—if not at full pressure, at something near it—to be able to take up this enormous increase of load in 10 minutes, as soon as ever their fires are brought forward and their dampers opened. (I am speaking here of such cities as London, or Manchester, or Glasgow. Of course, I know that there are happy places, like Rome or Aberdeen, where fogs are unknown, and where, therefore, all this provision against them is unnecessary.) I need hardly point out to you, after going over all these points, that it is improbable that the fuel consumption per indicated horse-power hour in electric light stations will ever reach, or can ever reach, anything like so low a figure as has often been reached in first-class steamers, where the engines and boilers work on continuously day and night at pretty much their most economical load. I will mention just one more point as to security of working in a station—the feed arrangements. Here in London I have several times run considerable risk of stoppage from this cause. A duplication of feed pumps and pipes is an obvious precaution, and one that probably everyone adopts. But few of us can keep water stored in sufficient quantity to last for more than three or four hours at full load, so that without special arrangements we are liable to be extremely inconvenienced by any accident happening to the mains of the water companies outside, which may compel them, on short notice or even no notice at all, to cut off the supply for a few hours. The best arrangements to meet this contingency vary in different places, but the engineer must not lose sight of the fact that the difficulty is one which may occur at any time, and from causes altogether beyond his control and even knowledge.

Outside the station the question of security comes in in connection with the mains. To a certain extent every station which uses either high or low tension feeders has some reserve in their very

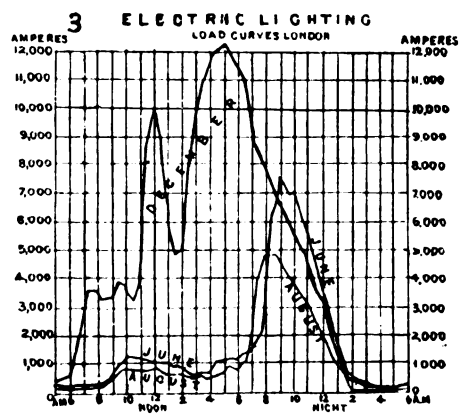

DIAGRAM 3.

number. When a company has more than one station, trunk mains led from one to the other are also a considerable security, as well as a great help to economy. Mr. Frank Bailey, of the Metropolitan Electric Light Company, has carried out a most excellent ring or looped main system on his high-tension distributors, by which he can make sure that any consumers can be supplied two different ways round the circuit, so that any accident to the mains may cause a minimum of inconvenience to a minimum number of consumers. In ordinary low-tension distributing networks the same result should be aimed at, although it cannot generally be obtained in what the mathematicians would call so "elegant" a manner. Many points occur in connection with the arrangement of electric mains which might be discussed in this connection as to the means for isolating and testing them, the desirability of putting large sections into parallel, or working them separately, etc., but these matters rather lie on the electrical than on the mechanical side of the subject, and I must abstain from discussing them here.

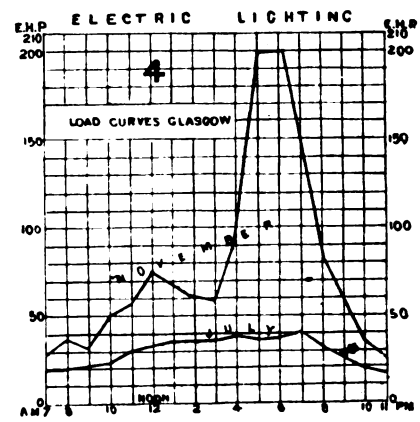

DIAGRAM 4.

I have next to speak of the regulation of an electric lighting station, as forming, along with its security, the two matters which chiefly affect the consumer of electrical energy. All that the consumer cares about is that the pressure in his house should be steady to the eye, and should be not less than its nominal value, and not very greatly above it. In all stations working on a large scale this constancy of pressure in the consumers' houses necessitates a constantly varying pressure at the station in order to make up for the loss of pressure in the mains, which is itself—wholly or in part, according to the system of supply—dependent on the amount of current passing through them. In an ordinary alternating-current station the pressure at times of maximum load exceeds that at times of minimum load by about 5 or 6 per cent. In an alternating-current station with low-tension distributors the excess may be about 12 or 15 per cent. In an ordinary low-tension station with three-wire system it may often be 20 per cent. The actual figure, of course, depends on the current density

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permitted in the copper; but the figures I have given illustrate the sort of percentage which different engineers have found it advantageous to adopt on a large scale. The primary requisite for proper regulation is obviously enough that the engineer shall know the actual value at each instant of the pressure which he desires to keep steady. In every case where low-tension distributing mains are used this pressure is the pressure at certain feeding points or at certain sub-stations, and it is best known at the central station by direct indication—bringing back pilot wires or potential leads from such points direct to the station, and connecting them to suitable voltmeters there. In these cases the regulation consists in so running the machines that the pressure indicated by these voltmeters is always kept at the desired amount. What appears to me a less satisfactory method is sometimes adopted—namely, the determination by calculation or by experiment of the loss of pressure corresponding to each output, adding this loss to the normal pressure, and regulating the dynamos to the corresponding sum, transformed if necessary. Apart from the fact that in this case the pressure actually received by the consumer is only estimated and not really measured, so that the thing measured is not the really important quantity, there is the additional drawback that the regulation is to a varying quantity instead of to a constant one, and is therefore less likely to be thoroughly satisfactory. In cases where distribution is by high tension with isolated transformers there is, of course, no direct means for keeping the pressure constant in the consumers' premises. If the distance between the nearest and the furthest consumer on any circuit is much less than the distance from the station to the nearest consumer, there may be a reasonably good regulation by the indirect means I have just described. In the case where the distance from the station to the nearest consumer is small in proportion to the distance from the nearest to the furthest, no such regulation is practically possible, and, in fact, in these cases the section of the copper must be made so large as to reduce the drop of pressure within negligible limits. By one or other of the methods which I have mentioned, and preferably, no doubt, by the use of pilot lines, the engineer in the station knows to what pressure he is to work. In every case the station must work at a varying pressure, although in some instances the variation may not be great. The highest pressure must occur always at the times of greatest load. Several means are at the disposal of the engineer for varying this pressure. Best of all I think, as being most convenient and most easily controlled, is the provision of sufficient additional resistance in the fields of the dynamos or exciters to enable the magnetic field to be altered by the mere moving of a switch having many contacts. Of course, to a certain extent this method wastes energy, but the quantity so wasted is so very small in proportion to the whole that it is not too high a price to pay. The switches can be placed upon the switch gallery so that the whole of the regulation may be done by the man in charge there, and be quite removed from the actual control of the engine-drivers. In order that this method may be satisfactorily carried out, the engines must be so arranged that they can be run entirely upon their governors, the stop-valves being opened fully as soon as the machines have taken up any load. In this connection it is worth while noticing that for continuous-current machines constancy of speed—which is, of course, to be distinguished from steadiness of speed, quite a different matter—is not in itself in the least a thing to be insisted on. The governor must be so set as entirely to prevent the engine racing in the case of a sudden short-circuit or other breakdown. But apart from this, an alteration of 5 per cent. or more is not a matter of the least moment. In fact, for practical purposes it is generally better that the governor should not be too finely set. Of course it may quite well happen that in the case of any one engine it may have to run throughout nearly its whole range of power at the same electrical pressure. If, therefore, the governor is so arranged as to allow of a drop in speed at full load, the field resistance must be so proportioned that, notwithstanding this drop, it can either keep the pressure constant or allow it to be increased within the desired limits. A much less satisfactory method of regulation is by means of the stop-valve—that is to say, by the engine-driver actually opening or closing his main steam-valve according to the pressure required. If this has to be done, each engine-driver must be able to see the pressure to which he has to regulate, and instead of regulation taking place by an easily moved switch in the hand of one man, it has to be carried out by the action of half-a-dozen stop-valves in the hands of perhaps as many different men. The enormous voltmeters which were made a few years ago, and I believe are still used in America in some places, having faces so large that they can be seen all over an engine-room, were designed in connection with this particular method of regulation. Regulation by field resistance was perhaps then not so well understood as it is now. At any rate, there can be no doubt which method is the better on all practical grounds. I have been speaking of efficiency of regulation so far as it affects or is affected by the gradual alterations of load such as are represented upon the diagrams on the wall. At times of full load this is practically the only matter of importance, because at such times any sudden increase or decrease of load are small proportionately to the whole load of the station. But in a station where the load every afternoon is, say, 1,000 kilowatts, it may quite well happen that in the early hours of the morning or during a bright forenoon the total load is little more than a hundredth part of this. In such a case the sudden throwing on or off of a motor without proper starting resistance, or even of a photographer's arc lamp under similar conditions, may increase or decrease the actual output by 20 or 30 per cent., or even more. Such variations are most often excessively sudden and of extremely short duration, so that they are particularly difficult to regulate for, and one must only be thankful that in the nature of things they can only occur at times when a little flickering of the light is not noticeable. In stations which are able to use batteries, there is no doubt that the battery acts practically the part of a flywheel in respect to these rapid variations.

I now come to my last section—namely, that of economy of working a station, still looking at the matter, of course, from the point of view of the mechanical engineer. Economy of working covers two sets of questions. There is, first, the reduction of direct cost of coal, oil, stores, water, and maintenance per unit or per horse-power hour; and, secondly, the obtaining of the greatest possible ratio between the net useful and the gross indicated horse-power. Taking these matters in their order, the question of coal naturally comes first. In an electric light station the cost of coal averages not far from four-tenths of the total working expenses. While, however, this matter is so important a one, it is yet one on which so much has been said and written that it need not detain us long. There is no one type of boiler, at least I do not know of any, which is better than all others under the conditions of an electric light station. Indeed, I would go so far as to say that from the point of view of economy there are five or six types of boiler which with equally good stoking will yield equally good and in every respect first-class results. Of course, any type of boiler may be badly arranged or badly proportioned, may be underworked or overworked; but if an engineer is not capable of so proportioning the boilers of whatever type he adopts as to give thoroughly good results, or of finding out whether his results can be improved, he had better at once take to some business which is less complicated than that of scheming an electric light station. It may no doubt sometimes be necessary in order to get a specially large output out of a boiler to provide it with one of the thousand infallible nostrums for that purpose. So far as my own experience has gone, however, I think that almost anything can be done with a really well-designed boiler, if only the engineer in charge knows how to handle his dampers and how to deal with his particular fuel under the conditions where coaxing is required. I have lately had some remarkable illustrations of the way in which a particular boiler could have its output increased 60 per cent. by the application of certain particular apparatus to it, and an exactly similar boiler could then, when the stoker had found out how to manage his fires, give exactly the same increase in output without any change being made in it whatever.

One thing which tells very much against the economy of an electric light station in respect to its evaporation per pound of fuel is the extent to which, during all day in many places, fires must be kept alight and pressures up in boilers capable of giving eight or ten times the actual output, and the extent to which in all stations fuel must be expended in getting boilers ready for the heavy load which comes on only once in 24 hours. These stand-by losses are not, as one would think, losses which get less as the output of the station increases, for the proportion which the stand-by boilers will bear to the actually used boilers at any moment will be practically constant whatever the output of the station. I have found that the total stand-by losses can be reduced in some cases to under 8 per cent. of the total fuel. Below this I have not yet succeeded in coming, although I hope a lower ratio will be obtained in the future. I am afraid it is often considerably more than 10 per cent. I believe that a far larger proportion of fuel waste in a station occurs through causes beyond the boilers than in the boilers themselves—that is to say, it is much more easy to get a good evaporation per pound of coal than a small consumption of water per indicated horse-power. Of the causes which contribute to this, the first is undoubtedly the very great loss which occurs by condensation in the steam-pipes and by leakage through drains and other valves before ever the steam gets to the engines at all. This is probably much greater in proportion in an electric light station than in most other places, because the requirements of security which I have already discussed necessitate the use of a very elaborate system of steam pipes, much more elaborate than is found in any other works. Not only does this system of steam pipes present a large radiating surface, and in various ways offer particular facilities for cooling the steam, but also the absolute necessity of keeping the pipes clear of water at all times, so that any section of them can be used safely at a moment's notice, involves the use of drain pipes and cocks. These necessary adjuncts to a system of steam-pipes, along with the apparatus which we call by courtesy steam-traps and use in connection with them, are a continual source of waste and annoyance to the engineer. The drain cocks get left open, or if they are shut they leak themselves open, the steam-traps require more looking after than the whole of the rest of the machinery put together, and altogether the whole system of pipes, drains, and traps probably cost us in many cases 10 per cent. of our whole fuel. In some experiments which I recently had made I have found the proportion to be 8·8 per cent., and I have reason to think that it is often far greater. I know of no heroic remedy which can be applied to the matter. Probably we have not in general paid sufficient attention to the proper covering of the pipes, including their flanges, and the flanges of the stop-valves. Certainly we have not somehow succeeded in obtaining steam-traps which will really work with any approach to permanent satisfaction under the trying conditions of every-day work. I hope that the use of superheated steam may be found very largely to reduce this particular cause of waste. Apart from this matter, I know no reason why any engine in an electric light station should not work every day and every hour at exactly the economy which the same engine reached on special trials made at the same load under the strict conditions of a specification. I have, in fact, on many occasions compared the running of engines in this way with the running of the same machines at the same loads on their original tests. When I have

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subtracted the amount of steam used for the feed pumps, the difference was never greater than I have found to be covered by the condensation losses which I have mentioned. Of course it is necessary to remember that engines working in a central station at very varying powers cannot be expected to give average results equal to those obtained at full power on trial. The results should be compared on the basis of tests at corresponding powers, and in order that this comparison may be carried out I always have a series of graduated tests made before taking over machinery.

After the cost of coal comes the cost of oil, water, and stores. These three items together cost in the average about one-fifth as much as the cost of coal alone. There is not much which can be said in circumstances like the present on the question of economy in this part of the expenditure, which really depends altogether on the good management of the engineer in charge. Such matters as the filtering and reusing of lubricants, and as the prevention of all needless waste of water, are obviously to be considered. It is perhaps generally sufficient for the engineer to find out the very lowest cost under these heads obtained in any other station, and to believe he can do a little better if only he tries hard enough. Cost of repairs and maintenance, still more than that of oil and stores, is one about which little can be formulated. There is no one type of engine or dynamo, so far as I know, that can be definitely said to be ahead of all others in respect of the fewness of its repairs. There are several types of machine which in the hands of careful engineers certainly give very good results, although it is somewhat difficult to compare the published figures under this head on account of the number of electrical stations which are still wholly or partially in the hands of their contractors, and in which therefore the full amount of repairs does not appear in the accounts.

I have mentioned that the economy of a station depends on two sets of considerations—namely, the actual quantity of fuel, stores, etc., per indicated horse-power hour, and, secondly, on the actual relation between the useful power and the gross power. It is obvious that it would be of no use to save 10 per cent. on the coal per indicated horse-power hour if that saving involved the use of machinery whose mechanical efficiency was 10 per cent. lower than it would otherwise be. This brings us face to face with the question which is always one of the most important to the engineer—namely, when he has got his horse-power in his engine as cheaply as possible, how to arrange so as to utilise the largest possible proportion of the horse-power thus obtained. The utilised horse-power is represented, in the case of an electric light station, by the energy passing through consumers' meters and paid for by them. Between this useful horse-power and the indicated horse-power of the engine there comes, first, the loss in the engine itself; then the loss between the engine and dynamo; thirdly, the loss in the dynamo itself; and, fourthly, all the losses between the terminals of the dynamo and the consumer's meter. As to loss in the engine itself, this does not appear to vary very much in different types of engine of first-class make. Approximately, it may be taken as about 10 per cent., sometimes a little less, of the full power of the engine, and as remaining very nearly constant at all powers as long as the speed is constant. Thus the mechanical efficiency of an engine which is 90 per cent. at full load, will be only about 80 per cent at half load. The efficiency of a dynamo at full load is much higher—it may be as much as 95 per cent., and may be still 90 per cent., far below half load. Thus the ratio of electrical to indicated horse power of a first-class steam-engine and dynamo may be 85 per cent. at full load, and something like 76 per cent. at half load. This assumes that the engine drives the dynamo direct, and that there is therefore no loss in transmission between them. I must confess that it remains a complete puzzle to me—a puzzle of which I have never found any solution—why engineers should wish, in addition to these practically unavoidable losses, to spend certainly 5 per cent., and on the average probably much more, of the whole of the power in their station in moving ropes or leather belts which have nothing whatever to do with the ultimate result, and which take up an enormous amount of space. The true solution of the matter really appears to me beyond all doubt to be either the use of quick-running engines, as is so common in this country, or of slow-running dynamos, as is so commonly the case on the Continent. I am, of course, here speaking of driving by steam-engines, not by gas-engines, in which latter case a number of other considerations come in. As most steam-engines take practically the same power per revolution to drive themselves, it is obvious that at low powers an increase of mechanical efficiency will be obtained by running at a less speed than that used for full power. This, of course, requires a specially arranged adjustable governor and a wide range of control in the field regulation. But I think it is worth doing in many cases The losses between the dynamo terminals and the consumers' lamps are, in a low-tension system, simply the losses in the leads. In a high-tension system they cover the losses—in general very much smaller—in the leads, but also those in the transformers as well. This is not a place nor a time for entering on a discussion of the relative merits of high and low tension systems—a matter which to anyone who is not a partisan of one or the other could certainly not be adequately discussed in any time short of the whole of that which has been occupied by this paper. Moreover, I need hardly point out that the choice of a system cannot possibly rest upon any one single point, such as the relative magnitude of the losses from a single cause. At present, so far as the figures to which I have access go, it may be interesting to you if I mention that in the case of a low-tension system where the maximum proportion of loss in the feeders is allowed to reach 20 per cent., or thereabouts, the actual average loss of energy throughout the whole year amounts to about 10 per cent. This is, of course, entirely due to ohmic resistance of the feeders themselves and of the network. I have no statistics by which I can compare feeder losses only in an alternating-current system with the figure I have just mentioned, but so far as those figures go to which I have access apparently the total losses both in mains and transformers in a high-tension system are not less than 25 per cent. of the energy generated. It is probable—indeed, I think it is certain—that this figure will be considerably reduced in the cases where banked transformers are employed with low-tension distributing mains. I hardly think, however, that it can be expected that the total losses will ever be so low as with a low-tension system.

5

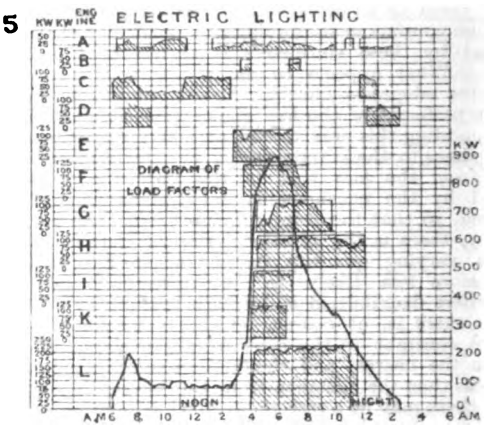

DIAGRAM 5.

I have already alluded to the extent to which the economy of a station is affected by the average load at which its units are run. To attain the greatest economy, it is obviously advisable that the machines actually at work at any moment should all be as nearly as possible fully loaded. The extent to which this can be actually reached in practice is shown in Diagrams 5 and 6. In one of these cases it will be seen that the average load during 24 hours is 78 per cent. of the load which would have been reached if the same machines had run the same number of hours each at its full power. In the other case the percentage is 58. What this particular percentage may be always depends on the exact relations between the load and the size of the units, and therefore in any station may vary very greatly at different times of the year. It is, however, not at all as easy as has often been thought to make the load-factor, to use the expression in the sense of the above ratio, very high. I find it difficult enough in many cases, even with the use of comparatively numerous units, to keep it up to an average even of 65 per cent. Of course it has to be remembered that, whether or not it is economical, the station engineer has to make certain that he has sufficient plant running to take up the work as it comes on. It is much the less of two evils that he should have every engine running every day half an hour before it is wanted, than that once a year he should be just too late with one or two of his machines. When the system of transformer sub-stations comes to be worked out practically a little more than it is at present, I believe that this load-factor problem will be found to be there even more troublesome than it is in the engine-room, and that the capacity of the transformers which the engineer will consider it necessary to keep on circuit in order that he may be always safe against breakdown of any of them, will be considerably greater than has been often assumed.

6

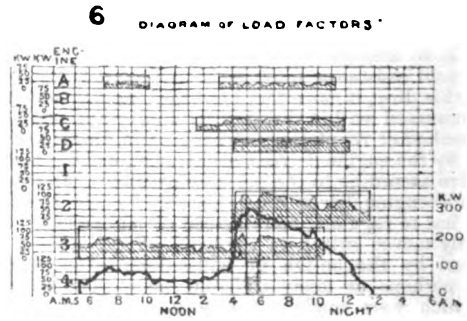

DIAGRAM 6.

I would only, in conclusion, mention one other matter. The mechanical engineer may be supposed to be of all others one who will most naturally take to the making of measurements of all kinds. Any passion which he may have for this has ample scope in connection with electrical work. Electrical measurements, at least with continuous currents, can be made more easily with simpler apparatus and more accurately than any other such measurements. I do not doubt that this fact has helped very much in the extremely rapid progress made during the last few years in matters electrical. Apart altogether from the more refined measurements which should be made from time to time for special purposes, there is no difficulty in getting continuous measurements, self-registered, with an average error of not more than 1 per cent. of the current sent out from each dynamo in a station. The average station volts can also be easily obtained with fair accuracy, and the amount of electrical energy developed

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at the dynamo terminals can thus be continuously measured as no other similar amount ever has been measured. This amount has to be compared with the amount of energy actually paid for—that is, with the sum of the readings on the meters of consumers. Some of the electrical companies have published with their annual reports detailed electrical balance sheets which show how very small the unaccounted for quantity now is. In the case of the Westminster Electric Supply Corporation it was over 5 per cent. in 1891, 3·16 per cent. in 1892, and was still further reduced to 1 28 per cent. in 1893. Unfortunately, with alternating currents measurements are very much more difficult and troublesome, and, consciously or unconsciously, I think this fact has, to a certain extent, hindered their adoption. There are now, however, alternate-current watt-meters practically free from error due to circuit induction, and capable of giving results with quite sufficient accuracy under the actual conditions of station practice. I believe that very great improvements in the economy of alternate-current working will date in every case from the time when the station commences to make accurate determinations, based on something different from the engine-driver's hourly entries in a log, of the true energy generated and the way in which it has been expended. I am sufficiently conscious of my own weaknesses to know that it is very dangerous for me to touch on the subject of measurements, especially at the very end of an address which has extended to so great a length as this. I will not, however, yield to the temptation, but will be content with simply having mentioned the matter. And, in conclusion, I will only say further that I hope the active electrical engineers among our members will forgive me for having spent an hour on such a very plain statement of matters familiar to them, if I have by this means been able to place before our non-electrical members some intelligible account of the problems at which we are working, looked at from their own point of view.

THE ROYAL SOCIETY'S CONVERSAZIONE.

The first conversazione of the season given by the Royal Society took place on Wednesday evening in the society's rooms at Burlington House, when the president, Lord Kelvin, received a large number of guests. There were, as usual, exhibits illustrating recent advances in almost every department of science. Chemistry alone was neglected, practically the only exhibit being that of Dr. J. H. Gladstone, who brought a number of bottles containing soluble and insoluble varieties of guncotton made 47 years ago. Electrical novelties were scarcely so well represented as last year. Sir David Salomons showed a series of beautiful experiments with vacuum tubes, and Mr. J. Wimshurst brought a model to illustrate his method of overcoming by means of induction the difficulty of carrying an electric cable on board an anchored and freely-swinging lightship. Perhaps the most remarkable of the purely scientific exhibits was the magnetarium devised by Mr. Henry Wylde, in appearance an ordinary geographical globe, but endowed with the same magnetic properties as the earth itself, so that a magnetic needle swung at any point on the surface showed the same dip and declination as it would on the surface of the earth. When the apparatus is set in motion the changes of dip and variation which have been observed since the sixteenth century are accurately reproduced on a small scale. This is brought about by an ingenious distribution of electric currents, one set flowing through insulated coils on the under surface of the thin shell of the visible globe, and another set through similar coils on the outside of a slightly smaller sphere arranged inside the first, and caused to rotate with its equator in the plane of the ecliptic of the outer globe. Prof. Silvanus Thompson performed by means of polyphase electric currents and rotary magnetic fields a number of experiments involving some of the darkest phenomena of molecular physics. Mr. R. E. Crompton, Prof. Moissan, and Mr. E. H. Griffiths had exhibits of appliances for turning electricity to practical use in the production of high temperatures in furnaces and in recording the degree of heat. Prof. Roberts-Austen also exhibited a thermo-electric pyrometer, which by recording variations of temperature in ink on a band of paper has revealed some hitherto unsuspected facts of much industrial importance as regards blast furnaces. Physical science, strictly so called, and its applications to mechanics were illustrated with more than usual detail. Mr. Eric S. Bruce showed some remarkable effects of the persistence of vision by projecting lantern views on a screen formed of a single lath revolving so rapidly as to assume the appearance of a transparent disc. The theory of magic mirrors was explained in the lecture-room, with illustrations projected on the screen, by Mr. J. W. Kearton, who showed how inequalities in a surface which had, subsequently to their formation, been so finely ground that the eye could not detect any break on the polished mirror flashed out in strong relief when a beam of electric light was reflected from it. The Japanese magic mirror, he explained, was produced as a "by-product" in grinding a piece of metal, on the lower surface of which a device had been cast in relief. Mr. A. E. Tutton demonstrated a new method of experimenting with pure monochromatic light of any wave-length, which was procured by means of a spectroscope provided with a second slit instead of an eye-piece, enabling a narrow strip of light to be selected from any part of the spectrum. Among the more purely mechanical contrivances of general interest was one in which Mr. Alley adapts the well-known transmission of force through a row of marbles to the purpose of ship's telegraphs and the opening or closing of engine valves. A mechanical pump for producing high vacua without the use of mercury, shown by Mr. H. A. Fleuss, attracted a good deal of attention; but a more popular exhibit was Mr. W. W. Beaumont's vibromotor, by means of which the energy which in most machinery is expended in producing vibrations may be diverted to do useful work and enable the machinery to run smoothly.—*The Times.*

LEGAL INTELLIGENCE.

WISE AND OTHERS v. THE METROPOLITAN ELECTRIC SUPPLY COMPANY, LIMITED.

The hearing of this case, which was commenced last sittings, was continued and concluded last week before Mr. Justice Stirling in the Chancery Division of the High Court of Justice. The action was brought by several leaseholders and occupiers of houses in Manchester-street, Manchester-square, asking for an injunction to restrain the defendants from using the works erected by them in Marylebone so as to create a nuisances or annoyance to the plaintiffs by noise and vibration, or by smoke, smuts, or grit given off by their fires. The plaintiffs complained that the vibration caused by the engines used to generate the electric current was so great as to cause the houses in the vicinity to tremble and all the doors and windows to rattle in such a manner as to seriously interfere with the comfort and enjoyment of persons living in the houses. Some of the plaintiffs are lodging-house keepers, and gave evidence to the effect that their respective businesses had been seriously affected by the nuisance, people who had been in the habit of taking rooms in their houses being compelled to leave and go elsewhere. Some of the witnesses described the effect of the vibrations as being similar to a slight continuous earthquake, while the rattling of the windows was like the beating of a kettle-drum. Others spoke to the difficulty of obtaining sleep and consequent injury to health. **Prof. Silvanus Thompson**, who had taken various observations as to the cause and effect of the vibration, was among the witnesses for the plaintiffs on Thursday last week. According to his view it arose partly from the fact that the electric works were built upon a site which formed part of the bed of the old River Tyburn, and that the soil was of such a spongy or porous nature that it readily conveyed the vibration caused by the engines. In the course of his experiments as to the effect upon the houses he had constructed an instrument for testing the strength and continuity of the vibrations. The instrument was produced in court, and by means of a phonograph his Lordship was enabled to hear the exact result of the experiment. The defendant company alleged that they had taken the best possible advice and adopted what means they could to mitigate the nuisance. They had since the erection of the machinery caused it to be supported upon solid shafts of masonry going down right through the spongy stratum into a more solid foundation, but, according to the plaintiffs' evidence, neither this course nor any other that had yet been adopted had put an end to the vibration.

Mr. Graham Hastings, Q.C., and Mr. Beaumont appeared for the plaintiffs, and Sir R. Webster, Q.C., Mr. Beale, Q.C., and Mr. Vernon Smith for the defendants.

Sir R. Webster, in opening the defendants' case, contended that they were not liable to have their works stopped by injunction No doubt the plaintiffs were entitled to compensation; indeed, that was the remedy which was expressly provided by the Acts under which the defendant company derived their powers. The company did not deny the fact of the vibration, but no case was made against them of negligence or want of skill. They derived their powers by virtue of the Electric Lighting Act, 1882, and the provisional order made thereunder which had since been embodied in an Act of 1889. In consequence of the impossibility of foreseeing all the effects of electric lighting operations, provisions were inserted in the Acts to the effect that where a company, in carrying out its powers without negligence, caused special damage they should be liable to pay compensation. The company was under the control of the Board of Trade, and could only establish its works with the sanction of that body and the local authorities, all of which had been obtained. The site had been sanctioned after an enquiry by the Board of Trade, and all the provisions of the Acts had been complied with. This was a case of a statutory undertaking for the supply of electricity which might involve special damage, and yet, subject to the works being properly carried on, such damage was to be met by compensation only. There was an absolute obligation on the company to supply electricity to the district, and, in the absence of negligence, the action for an injunction was not maintainable.

The witnesses for the defence were examined at the conclusion of Sir R. Webster's opening. Their evidence was directed to show that every effort had been made by the company to do away with or minimise the vibration and noise. Both the engineers of the company and Prof. Kennedy, whom the company had consulted, expressed their belief that the remedial measures which were now being taken would ultimately result in the cessation of the vibrations. It appeared from their evidence that, in addition to the vertical shafts of masonry which had been sunk down to a solid foundation and on which the engine bed rested, the company were now putting in a series of diagonal struts, similarly carried through the spongy stratum and embedded in the hard clay below, in order to put a stop to any lateral motion by the machinery, which was now believed to be the cause of the vibration.

At the conclusion of the evidence, **Mr. Beale, Q.C.**, for the defendant company, referred to Mr. Justice Kekewich's decision (which was given in our last issue) in the case of Meux's Brewery

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Company *versus* the City of London Company. He contended that that did not completely cover the present case. The plaintiffs had not adduced such evidence of interference with health and comfort as to entitle them to maintain an action for nuisance, and certainly not for an injunction.

On the resumption of the hearing on Tuesday, **Mr. Graham Hastings, Q.C.**, was heard in reply upon the whole case.

Mr. Justice Stirling said that this was an action brought by five plaintiffs against the defendant company, and it sought to restrain the company from carrying on their business in such a way as to cause a nuisance to the plaintiffs by three different modes—viz , by vibration, noise and smoke, smuts and grit. The defences put forward by the company were twofold—first, it was said that they did not carry on their business in such a way as to cause an actionable nuisance to the plaintiffs ; and, secondly, that even if they did the only remedy of the plaintiffs was by compensation under Section 17 of the Electric Lighting Act, 1882, and not by way of injunction or damages. With regard to the second of these defences his Lordship considered it unnecessary for him to go into the subject, because it so happened that since the hearing of this action was first commenced the identical question had been raised before Mr. Justice Kekewich in a case decided by him during the present sittings (Meux's Brewery Company *v.* City of London Electric Lighting Company, reported in our last issue). Mr. Justice Kekewich appeared to have fully considered the question, and dealt with all the material points. If a few of the points taken in this case had not been touched upon, his Lordship did not think that, had they been taken before Mr. Justice Kekewich, they would have affected the conclusion at which he had arrived. Under these circumstances it would not be right for him (Mr. Justice Stirling) to enter into the question again. He therefore should proceed upon the basis of the conclusion at which Mr. Justice Kekewich had arrived upon the question of law, and accordingly must start with the assumption that the defendant company was not entitled to carry on its works in such a way as to cause a nuisance to its neighbours. Upon that two questions arose—first, whether, in fact, the nuisance was caused by the works ; and, secondly, what was the remedy of the plaintiffs in respect of it. On the question of what constituted a nuisance his Lordship referred to the case of Walter *v.* Selfe, where V.C. Knight-Bruce defined it as an "inconvenience materially interfering with the ordinary comfort physically of human existence, not merely according to elegant or dainty modes and habits of living, but according to plain and sober and simple notions among the English people." That had been referred to and approved of in many cases, and particularly by Lord Selborne in Fleming *v.* Hislop, where he said, referring to Walter *v.* Selfe, that the case and "all the cases which have followed it have laid down this proposition in substance, and very nearly in words, if I am not mistaken, that what causes material discomfort and annoyance for the ordinary purposes of life to a man's house or to his property is to be restrained, subject, of course, to any question which the circumstances of the particular case may raise, and that although the evidence does not go to the length of proving that health is in danger." His Lordship then referred to the evidence as to the existence of the vibration, and to the means which had been adopted by the defendants to get rid of it, and said that it must be taken upon the evidence that there was, in fact, a substantial amount of vibration in the plaintiffs' houses due to the working of the defendants' engines. Did that in law constitute a nuisance? The test to be applied was that suggested by V.C. Knight-Bruce and adopted by Lord Selborne—viz., did it cause "material discomfort and annoyance for the ordinary purposes of life?" The plaintiffs spoke very forcibly as to the vibration. They also mentioned the fact of noise, but it seemed that the real substantial complaint was as to the vibration. The complaint as to the noise might perhaps be regarded as a kind of appendix to the vibration. His Lordship then further examined the evidence upon the question of the effect of the vibration upon the houses, remarking that one of the most remarkable features of it, as pointed out by the scientific witnesses, was its fitfulness. Sometimes it would be felt more in one room and sometimes in another, now in one house and now in another. But, taking the evidence of the witnesses as honest statements giving a fair account of what was experienced in the houses, his Lordship came to the conclusion that a case was made out of interference with the enjoyment in the ordinary way of these houses. The ordinary occupation of people living in them was interfered with, and there was evidence that the occupants were unable to enjoy their ordinary rest. The evidence had been given with moderation and without exaggeration, though perhaps a little colouring had been introduced ; but a substantial case of nuisance from the vibration had been made out. As to the noise occasioned by the machinery, his Lordship did not come to the same conclusion. It was not a serious matter of complaint. Still less so was the complaint as to smoke. He accepted the statement of the defendants' engineer that during the coal strike inferior coal had to be used, which might have caused some annoyance, but there was no case for an injunction or damages as to either noise or smoke. That, however, was not a serious part of the case, and had not materially increased the costs of the action. It followed that the Court ought to grant an injunction and an enquiry as to damages. That injunction and enquiry, however, would be postponed for a time. The company had been unfortunate, and ever since October, 1892, they had done their very best to remove all ground of complaint. If they had not succeeded, it was no fault of theirs. The case presented an engineering problem which was apparently entirely new and very difficult, and the company ought to have a fair opportunity of completing the remedial works upon which they were still engaged. Having regard to the difficulty of the subject and the uncertainty of the success of the means which could be adopted, it was fair to suspend the injunction for three months. The injunction and enquiry as to damages would be confined to the subject of vibration, and the defendants would not be precluded from applying, if necessary, for a further extension of time. The defendants must pay the costs of the action.

ALDIN v. LATIMER CLARK AND CO.

In this case, which was argued last session, **Mr. Justice Stirling** gave judgment on Tuesday in the Chancery Division of the High Court of Justice. The plaintiff was the lessee of certain premises at Richmond, in Surrey, and by this action he sought to restrain the defendants, who were the owners of adjoining property, upon which they had erected works for the purpose of supplying the town with electric light, from violating in various ways his rights as lessee. The plaintiff derived his title from a Mr. Munro, who was also the predecessor in title of the defendant company. Previously to 1878 Munro carried on business as a stonemason and timber merchant upon the premises now occupied by the plaintiff and the defendants. In April, 1888, he agreed to sell the goodwill of his business of timber merchant to the plaintiff for £1,000, and to grant him a lease of that portion of the property on which that business was carried on. Accordingly, on July 1, 1878, Munro granted the plaintiff a lease of the premises in question with the buildings thereon for 21 years at the yearly rent of £160, with a right of way over a portion of the adjoining property. The lease contained a covenant by the plaintiff to carry on upon the premises throughout the term "the timber trade heretofore carried on by the said John Munro," and Munro covenanted for quiet enjoyment in the usual terms. Under a subsequent agreement the plaintiff, with the consent of Munro, erected an additional shed or building upon the demised property, Munro advancing a portion of the cost and the plaintiff agreeing to pay an additional rent in respect of the shed so erected. Munro remained in occupation of the adjoining property, and carried on there his business of a stone merchant down to his death in 1892. After his death his devisees sold the whole of his property (including that demised to the plaintiff) to the defendant company, who proceeded to erect thereon their electric lighting works. The matters mainly complained of by the plaintiff were the following: (1) interference with the access of air to the drying-sheds used in connection with the timber business; (2) interference with the right of way granted by the lease of July 1, 1878 ; (3) interference with certain ventilators in the plaintiff's stables ; (4) user of the defendants' property so as to heat the plaintiff's stables and render them unhealthy, and so as to endanger the plaintiff's premises and stock-in-trade and cause risk of damage by fire. The chief complaint, however, on the part of the plaintiff was that the works erected by the defendant company injuriously affected the access of air to the drying-sheds so as to render them substantially less useful for the purpose of the timber business which the plaintiff was bound to carry on upon the demised premises, and it was contended on his behalf that the acts of the defendants constituted either a derogation from the grants contained in the lease, or else a violation of the covenants for quiet enjoyment therein contained.

Mr. Graham Hastings, Q.C., and Mr. Ingpen appeared for the plaintiff; and Mr. Finlay, Q.C., Mr. Beale, Q.C., and Mr. Marcy for the defendants.

Mr. Justice Stirling, after stating the facts, said that the legal principle invoked on behalf of the plaintiff appeared to be recognised in several modern cases. Thus in North-Eastern Railway Company *v.* Elliot, a case relating to a right of support, Lord Hatherley (then Vice-Chancellor Wood) said : "If a landowner conveys one of two closes to another he cannot afterwards do anything to derograte from his grant ; and if the conveyance is made for the express purpose of having buildings erected upon the land so granted, a covenant is implied on the part of the grantor to do nothing to prevent the land being used for the purpose for which, to the knowledge of the grantor, the conveyance is made." That was the principle established by Caledonian Railway Company *v.* Sprot, where Lord Cranworth said that if a grant was made expressly to enable the grantee to build his house on the land granted, then there was an implied warrant of support, subjacent and adjacent, as if the house had already existed. In Robinson *v.* Kilvert, a landlord let the floor of a house to a tenant for a paper warehouse, retaining a cellar immediately below. He afterwards commenced a manufacture in the cellar which required the air to be hot and dry, and employed heating apparatus which raised the temperature in the demised portion very considerably, with the result that some kinds of paper warehoused there were injured and made less valuable, though paper generally did not suffer. The landlord was ignorant at the time of the letting that the tenant was going to store any particular kind of paper which was likely to be deteriorated by heat which would not hurt paper generally, and it was held that the landlord was not liable either on the ground of nuisance of derogation from his grant, or breach of the convenant for quiet enjoyment. His Lordship then referred to the judgments of the Court of Appeal in that case, and, continuing, said that the result of those judgments appeared to be that where a landlord demised part of his property for carrying on a particular business he was bound to abstain from doing anything on the remaining portion which would render the demised premises unfit for carrying on such business in the way in which it was ordinarily carried on, but that this obligation did not extend to special branches of

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the business which called for extraordinary protection. Reference was made in argument to the cases which have arisen as to the right of access of air to buildings. It was laid down in Aldred's case that where there is a grant of windows, then "for stopping as well of the wholesome air as of light an action lies, and damages shall be recovered for them, for both are necessary." In Hall *v.* Lichfield Brewery Company damages were given in respect of an obstruction of air to apertures (in the nature of windows) in a slaughter-house, the right having been gained by user for between 30 and 40 years. Again, it was held in Bass *v.* Gregory that the right to the uninterrupted flow of air through a definite channel over adjoining property could be acquired by user for a sufficient period, and an injunction was granted to restrain interference with it. On the other hand, it was held in Webb *v.* Bird that the owner of a windmill was not entitled to complain of the erection by the defendant of a schoolhouse so as to obstruct the access of currents of air to the mill enjoyed over the defendant's land for upwards of 20 years. His Lordship, after referring to other authorities, said that these cases dealt mainly with the subject of acquisition of the right by user, and not with the rights conferred by deed or grant. The judgments to which he had referred to show that under a grant expressed in general terms, and not made for any specific purpose, the grantee would not acquire a right by way of easement to the access of air, except where such right was enjoyed through a definite aperture in the nature of a window on the property granted, or through a definite channel over adjoining property. On the other hand, his Lordship saw nothing in these cases inconsistent with the principle recognised in Caledonian Railway *v.* Sprot, North-Eastern Railway Company *v.* Elliot, and Robinson *v.* Kilvert, that the grantor of land to be used for a particular purpose is under an obligation to abstain from doing anything on the adjoining property belonging to him which would prevent the land granted from being used for the purpose for which the grant was made. This seemed to accord with the general rule that a grantor may not derogate from his own grant, and to be far more consonant with justice than that contended for by the defendants—viz., that the grantee had no right of action unless the grantor could be proved to be acting maliciously. In the present case the lease was not merely granted for the purpose that the land demised might be used by the plaintiff for carrying on his business as a timber merchant, but it contained an express covenant binding him to carry on that business. In his Lordship's opinion, Munro became subject to the obligation to abstain from doing anything on his adjoining property which would substantially interfere with the carrying on of that business in the ordinary course; and that obligation bound the defendants as assigns from him, subject to the existing lease. His Lordship then proceeded to consider the evidence, and upon it came to the conclusion that some injury to the drying-sheds had been made out, but not sufficient to justify the granting of an injunction. The plaintiff was entitled to an enquiry as to the damages he had sustained by reason of the buildings rendering the sheds less fit for use in the ordinary course of his business as a timber merchant.

MUIRHEAD AND ANOTHER v. THE COMMERCIAL CABLE COMPANY.

On Saturday judgment was given by Mr. Justice Kennedy in the Queen's Bench Division for the plaintiffs in this action, which occupied the Court from February 28 to March 7 last. The plaintiffs, J. and A. Muirhead and H. Arnand Taylor, the patentees and proprietors of certain patents for the system of duplicating cables known as the "Muirhead Duplex System," sued the defendants, a foreign company incorporated under the United States laws, the owners of certain cables connecting North America and Ireland and Ireland and France, to recover royalties under a written agreement, dated January 2, 1884, giving the defendants a license to use certain patents of the plaintiffs in consideration of a yearly payment of £1,250, to be increased in certain eventualities. The sums claimed were £1,879. 18s. 9d. for royalties from July to September, 1891, and £1,685. 2s. 8d. for royalties from September to December, 1891, making in all a sum of £3,566 odd. The defendants admitted the deed of contract, and also a *primâ facie* liability under it. But they alleged that the patents in question had run out at a certain date, and they paid all the royalties due from them up to that date into court. Thus, the defendants undertook the responsibility of proving that the plaintiffs' American patent of 1880 terminated at the same date as their English patent by the law in the United States that enacts that "every patent granted for an invention which has been previously patented in a foreign country shall be so limited as to expire at the same time with the foreign patent." In order to establish that contention it was necessary in effect to show that the plaintiffs' American patent of 1880 was substantially identical to their patent of 1876. The plaintiffs pleaded that such a course was not open to the defendants on the doctrine that a licensee cannot attack the validity of the patent for which the license is granted any more than could a lessee attack his landlord's title though he could show that the lease had expired.

Mr. Finlay, Q.C., Mr. Bousfield, and Mr. E. H. Pollard appeared for the plaintiffs; and Sir Richard Webster, Q.C., Mr. F. S. Moulton, Q.C., and Mr. A. J. Walter were for the defendant company; and Mr. Carpmael held a watching brief for an interested third party.

Mr. Findlay, in opening the case for the plaintiffs, said the action practically involved a sum of some £45,000, and he pointed out what were the issues of law and fact, and proceeded to give a description of Muirhead's duplex system of telegraphy. The learned counsel then proceeded to deal with the case from its legal aspect, and contended that, on the authority of Clark *v.* Adie, the defendants as licensees of the American 1880 patent, were estopped from attacking the validity of that patent, which, he argued, they did if they attempted to show that it was anticipated by the 1876 patent. But, even assuming that at law the defendants could go into this question, he submitted that the invention claimed by the plaintiffs in the 1880 patent was for a certain combination of the rheostat, the condensers—one on each arm of the bridge, and another on the bridge itself below the receiving instrument, which combination was, he contended, entirely novel, and the results it gave were of the greatest commercial value. It produced a greater rapidity of transmission and a more perfect balance than had ever before been the case. In judging whether this combination was new or not he submitted that his Lordship should not be guided by the same considerations as would influence him in construing a combination of mechanical movements under ordinary circumstances, but to be guided rather by the results obtained. For all electricians agreed that the electric conditions and surroundings of a submarine cable were so very complicated and intricate that they found it impracticable to sit down and work out in the ordinary way the mathematical formulæ in connection with any set of combinations (in a duplex system) so as to arrive at what would be the definite result. It was found easier to make changes in the system by a variety of practical experiments, and to watch the results. The least little alteration in the exact position of any one of the apparati might produce most different results—results that could not, as he had said, be worked out in a moment by set mathematical formulæ. He hoped, therefore, that the learned judge would not be misled into adopting a view that, because some of the plans or arrangements for duplexing, as shown in the 1876 patent, were somewhat similar to those shown in that of 1880, therefore the two patents were substantially the same. He would ask his Lordship to look at the practical results obtained by each system, and to judge from them as to difference or otherwise.

Prof. Silvanus Thompson, F.R.S., Lord Kelvin, F.R.S., Sir Frederick Bramwell, Mr. George Mockeridge, Mr. John Imray, Mr. Herbert Taylor, Prof. J. T. Bottomley, the Messrs. Muirhead, and Dr. Hopkinson, F.R.S., were all called for the plaintiffs and examined at length upon the scientific aspect of the case and in support of the plaintiffs' points.

Sir R. Webster, for the defence, said there were in it two issues—one of law, the other of fact. His Lordship would have to deal with the American statutes and cases so far as they affected the case and apply them accordingly. For by one of the clauses of the deed of agreement between the defendants and the plaintiffs it was agreed that "all questions arising thereon should be determined by a competent English tribunal as to the jurisdiction of which the parties hereto bind themselves beforehand to submit." There were, he said, three or four authorities of American patent law to the effect that, although upon the grant of an American patent there may be no limit or no reference to the foreign patent, yet the grant came to an end conterminously with the latter if the Court were satisfied that the two inventions in the respective patents were substantially identical, and even in an action for infringement brought against a person who is admitting the validity if the Court is satisfied that the inventions are the same.

Mr. Justice Kennedy said he had looked at the authorities (Canan *v.* Pound Manufacturing Company, 23 Blatchford, 173, and Bate Refrigerating Company *v.* Hammond, 129 U. S. Repts., 151), and he agreed that it was so, and he had understood Mr. Finlay to do the same.

Mr. Finlay said he did, but he submitted that it was not open to the defendants (licensees) to attack the validity of the plaintiffs' 1880 patent.

Sir R. Webster said he did not attack its validity, but it was open to the defendants to show that, the term of, so to speak, the governing patent having expired, they were no longer liable to pay royalties to the plaintiffs. The United States laws allowed an inventor to patent at any time, provided that the invention had not been brought into public use in that country for more than two years before The defendants only argued that by the United States law this 1880 patent came to an end at the same date as that of 1876. The true position of a licensee was clearly defined in Crossley *v.* Dixon and Clark *v.* Adie. As regarded the Canadian patents, he understood that their identity with the 1880 one was now admitted, and he need not discuss them further. Passing on to deal with the scientific part of the case, he said that when all the many technicalities with which the subject had been, perhaps unavoidably, overlaid were put on one side, the issue was a very simple one—viz., aye or no, was the patent of 1880 substantially identical to that of 1876? If he satisfied the Court that it was, then his clients were entitled to judgment on the authority of Siemens *v.* Sellers. It was, he said, a remarkable fact that if this 1880 patent was new and such an improvement as it was now said to be, it should never have been patented by the plaintiffs in England. He would suggest that what really had happened was this, that in 1880 the plaintiffs had discovered that the particular combination—the subject of their 1876 patent—shown in Figs. 2 and 3 of that specification was practically the best of all the combinations therein described, and that that being so they picked it out and claimed it, when they came to describe that part of their 1876 patent which they were anxious to protect in America in 1880. It was a clear case of a patentee patenting in the States that portion of his old English patent which he had found by experience to be the most useful. The only invention which the plaintiffs could claim in their 1876 patent was the placing the

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condensers in the bridge arms, like their 1880 patent, and it was, he said, a complete afterthought for them now to say that that was not what they had then claimed. He contended that any skilled electrical workman carrying out what was described in the 1876 specification not only could, but must produce substantially identical results as he would if working on that of 1880. He concluded by directing the attention of the Court to the material admission which he had got from the different expert witnesses in favour of his general contention.

Prof Andrew Jamieson, Mr. J. Swinburne, Mr. H. R. Kempe, Mr. John Gott, Mr. Frank Jacob (manager to Messrs. Siemens Bros.), and **Sir H. C. Mance** gave scientific expert evidence in favour of the defendants' contention.

Mr. Moulton summed up the case for the defendants, contending, on the evidence of all the expert witnesses, it was clear that the patent of 1880 was substantially the same as that of 1876. In concluding, he briefly alluded to the legal aspect of the case, saying that his friend Mr. Walter would call his Lordship's attention to the American law on the subject. He agreed with Mr Finlay that the true test, according to the American cases, was not whether the American patent would be an infringement of the foreign patent, but whether the foreign patent would be an infringement of the American patent.

The learned **Judge** pointed out that one of the American judges put it rather differently— viz., that what would infringe the American patent would infringe the English patent; and what would infringe that was made free to the public by the expiration of the English patent.

Mr. Finlay said their contention was that the 1880 patent was for a combination of old elements contained in that of 1876, and that anyone wishing to use the patent of 1880 would have to obtain the license of both patentees.

Mr. Moulton resumed, contending that the true test was whether a person working a patent like the 1876 one would not be infringing that of 1880. He clearly would upon the evidence, and, therefore, by all the American cases and the statute, the 1880 patent must expire on the same date as that of 1876. The defence in no way attacked the validity of the American patent *per se*

Mr. A. Walter argued for the defence (1) that the facts established sufficient identity between the two patents of 1876 and 1880 to make the latter expire at the same date as the former—viz, in 1891—within the principles of American statute and case law, by which the 1880 patent was governed. Secondly, he argued that it was not necessary under Section 4,887 that the American patent of 1880 should be limited on its face so as to be conterminous with that of 1876 in England. He next dealt with the point, made by the defendants, that the 1880 patent was applied for not by the true inventor, John Muirhead, but by Alexander Muirhead, upon a communication to the latter from the former. The learned counsel concluded by directing the Court's attention to the Canadian statutes, so far as they affected that part of the case relating to the plaintiffs' Canadian patents, which were admitted to be identical with the 1880 patent.

Mr. Bousfield then addressed the Court for the plaintiffs, and, reviewing the evidence of fact, contended that the identity of the two patents had not been established, that of 1880 being one for a special and improved combination of certain parts of that of 1876. He referred to the American cases cited by Mr. Walter, but argued that they were all distinguishable from the present case, inasmuch as in all of them the question of identity was clearly established to the Court, which was not, he submitted, the position here.

Mr. Finlay followed upon the law.

Mr. Justice Kennedy, in delivering judgment in favour of the plaintiffs, outlined the nature of the claim, and referred to the written agreement of January 2, 1884, under which the plaintiffs had granted the defendants license to use their patents in connection with duplex telegraphy upon certain terms. The only important part of that agreement for the purpose of deciding the case was, he said, the first article thereof—viz.: "The inventors grant to the company the right to apply this said patented duplex apparatus to the above-named cables. This grant is made for the whole period during which the patents shall last. . . ." The clause further bound the plaintiffs—the inventors—to give to the defendants all the benefits of any improvements which they might make in their then system during the currency of this license. For the purposes of this action, his Lordship said, it might be taken that this agreement was carried out by both parties up to July 1, 1891, and it was the quarterly payments due subsequent to that date down to December 25, 1896, that the plaintiffs now sought to recover. The action had an interest far beyond those amounts, however, for if the plaintiffs were entitled to recover them, it followed that they were entitled to similar quarterly payments for several succeeding years also. The issue which was raised was, Was Mr. Alexander Muirhead's patent, No. 234,490, dated November 16, 1880, a patent which, in the language of the article of the agreement he had referred to, was "lasting" after July 1, 1891? The plaintiffs contended that it was, and if it were not the defendants were entitled to judgment. The determination of that issue involved some important issues of law and some complicated questions of fact of a scientific and highly technical character, the trial of which occupied several days. The plaintiffs' patent of 1880 was granted by the American Patent Office, and was expressed to be for 17 years from November 16, 1880. *Primâ facie*, therefore, it would last until November 16, 1897; but, being a United States patent, it was governed by American law, which enacted that "every patent granted for an invention which has been previously patented in a foreign country shall be so limited as to expire at the same time with the foreign patent, or, if there be more than one, at the same time with the one having the shortest term, and in no case shall it be in force more than 17 years." Having also referred to Rule 162 (United States Rules of Practice), his Lordship said it had been, in his view, decided by the American cases that, although an American patent had not upon its face been limited, but contained an express grant of the patent rights for the full term of 17 years, nevertheless, by operation of law, if the invention had, in fact, been primarily patented abroad, and the foreign patent had expired before the 17 years' term had run out, the American patent would expire at the same time. It was also settled law that the United States statutes were not to be interpreted as invalidating *ab initio* a patent wherein, although it is for an invention previously patented abroad, the grant was not limited, but was for the full term of 17 years. The statutes were to be construed simply as curtailing the effect or duration of the grant. In other words, the patent is a valid grant, but is good only for the shorter term, and expires at the expiration of the foreign patent of which it is a copy. That being the state of the American law as to patents, the defence to the plaintiffs' claim was that the plaintiffs' American patent of 1886 was for "an invention which had been primarily patented in a foreign country"—viz., the English patent granted to Mr. Muirhead in 1876, No. 2,564 which expired not later than July 1, 1891—and that the American patent, being in substance the same as that of 1876, the former, by operation of American law, terminated on July 1, 1891, though on its face it was expressed to last for 17 years from November 16, 1880. In reply to that the plaintiffs raised two sets of contentions, one purely legal and the other partly legal and partly of fact and based upon the construction of the English and American patents and the inferences to be drawn from the scientific evidence. First, as to the law. The plaintiffs say that, as between a patentee and a party charged with infringing the patent, the alleged infringer may, according to American law, succeed by proving that the American patent has expired because of the expiration of a prior foreign patent granted for the same invention, although the duration of the American patent has not been limited, as it ought to have been, upon its face to the duration of the foreign patent; yet that line of defence is not open to a licensee as against his licensor, because to establish it the licensee had to attack the validity of the patent. The learned Judge held that the plaintiffs' view upon that point was wrong, and that the defendants were not estopped from setting up the defence that the American patent had expired with the English one of 1876, if those patents were the same in substance and effect. He also decided that on the evidence the fair inference was that the patent of 1876 had been granted with Mr. Alexander Muirhead's knowledge and consent, and that the United States law was applicable if it was found, in fact, that the English patent of 1876 anticipated that granted in America in 1880. Lastly, he had been asked to hold that he could not, sitting here, find that the American patent had expired without proof of a decision in the United States Court to that effect. This action was, however, he pointed out, brought upon a written agreement, which expressly provided that it was to be construed as an English contract, and that all questions or disputes arising thereout should be determined by a competent English tribunal. How could it, therefore, he said, be successfully argued that he ought to refuse to try the questions raised in this action between the parties? The learned Judge continued: Having thus dealt with the various legal contentions, he came to the more difficult but most interesting part of the case—viz., were the defendants right in their allegation that the plaintiffs' American patent of 1880 was the same invention as that for which the 1876 patent had been granted them in England? Unless the defendants were right in that the defence to the action entirely failed, and the plaintiffs were entitled to judgment. In dealing with this portion of the case, the learned Judge, after some prefatory remarks upon the highly technical nature of the evidence and the very convenient mode in which the American cases and statutes had been laid before the Court, proceeded to deal with the general principles established in these American cases as applicable to this action, and observed that, as laid down in Brush Electric Company *v.* Julien Electric Company, if there were any doubt upon a question of the identity of an American patent with that of a foreign one the patentee was entitled to the benefit of such doubt, as the policy of the law was to support the patentee's rights. The learned Judge also referred to the case of Siemens *v.* Sellars and Judge Cox's judgment in the Electric Accumulator Company *v.* Julien Electric Company, Limited, upon the questions of infringement and as to the true test of identity in patents, and, continuing, asked—(1) Is the principal invention of the American patent of 1880 found in the English one of 1876? (2) Is the subject-matter of the one the same as that of the other? (3) Could both the patents have been granted in America? (4) Would a person skilled in this art, from reading the description of the English patent of 1876 be able therefrom to construct the apparatus described and claimed in the American patent of 1880? Those questions involved, in his opinion, the principles deducible from all the American cases as to the identity of the patents of 1876 and 1880. The claim of the 1880 patent was one of the narrowest kind, and was for a particular combination only. The elements forming that combination were admittedly old. "My invention," says the patentee, "relates to duplex telegraphs of the class worked on the bridge or differential system." "The object is more especially to reduce the retardation of the signals and increase the speed of transmission of submarine telegraph lines, which ends I attain by certain novel combinations and adjustments of old instrumentalities set out in the claims at the end of this specification." The defendants, in order to succeed, must establish beyond all doubt that this particular combination of old instrumentalities—the working of which undoubtedly, said

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the learned Judge, produced commercially better results than had ever been obtained before—was to be found in the earlier patent of 1876. Put shortly, the distinctions seemed to him to consist in the method and means of adjustment—that was, the maintaining the proper balance. He was satisfied upon the expert evidence that the introduction of the "three-terminal" rheostat of low resistance placed at the apex of the bridge arms, and therefore in such a position as not merely to afford an easy and sufficient means of varying the resistances so as to get the ratio which gave a balance, but also to maintain the sum of the resistances of the two bridge arms constant, was a very important part of the 1880 combination. Having in some detail described the differences in his judgment, as established by the evidence, between the two patents, the learned judge, in conclusion, said that on all the evidence he was clearly of opinion that the patent of 1876 did not contain the same combination as was found in the American patent of 1880, and that in his opinion the latter was a good and novel patent. There would therefore be judgment for the plaintiffs for £3,566. 1s. 5d., and costs.

Execution was stayed for 21 days to consider the question of an appeal.

On Monday, the question was raised as to whether or not the plaintiffs were entitled to interest at 5 per cent. upon the amount of the royalties which were found to be due to the plaintiffs from the defendants under the agreement of January 2, 1884.

Mr. Walter said that the question involved several points which would require some time to argue, as he was prepared with several cases in point to which he would have to refer. As his Lordship was engaged trying cases with juries, it would be inconvenient to argue the question now; and he would therefore ask his Lordship to fix a day when it would be more convenient.

Mr. Pollard, for the plaintiffs, said that he was quite prepared to argue the points at once, and would not occupy more than six or seven minutes.

Mr. Justice Kennedy said the question involved a considerable sum of money, and he was willing to hear the arguments at any time which counsel might agree upon, either during or after the regular hours for sitting. If, therefore, counsel would agree upon an hour and day and let him know, he would meet them in any way he could.

The matter then dropped.

COMPANIES' MEETINGS.

PHONOPORE COMPANY.

The fifth annual general meeting was held on Monday at Winchester House, E.C., Mr. Henry Seebohm (the chairman) presiding.

The **Chairman**, in moving the adoption of the report and balance-sheet, said that the late Board, when it took over the management of the Company from the previous Board, took it over with a light heart. They thought that all the difficulties had been overcome. Members of the late Board and electrical experts whom they consulted, especially Mr. Spagnoletti, took a very sanguine view of the Company's position. They could, therefore, well imagine that, in the face of such strong evidence in favour of its perfection, it took them a very long time before they were absolutely convinced, as they were now, that what they possessed was little more than a pretty electrical toy. There were great difficulties to be overcome in the practical working of the phonopore. They were, no doubt, in an ideal position, and not in a practical one, and those difficulties were continually developing from day to day, and from week to week correspondence was laid before the Board, with one almost uniform result—namely, everybody was anxious to use the instrument, and all who tried it were very much pleased with it; but by-and-by they found that the adjustment of it was so delicate that it was more than the average telegraphic clerk was capable of grappling with. The Board had, therefore, constantly to send out messengers to put instruments right which, for some reason, had gone wrong. He had no doubt that Mr. Langdon Davies believed every word he uttered, although those statements had not been borne out by facts. The directors now found that when they sent out instruments they were followed by more orders, and that in itself was a satisfactory matter. Those who took the instruments were not grumbling at their imperfections, but at the price. The Company was now sending out people to fix up fresh instruments, and the results from those instruments had been much more satisfactory than they were 12 months ago. The directors had made several important improvements, including a new receiver and a new phonophone sounder, and they were now able to work their instrument upon a single-needle key, as well as on the Morse system. After alluding to the satisfactory report on the alterations and improvement in the instruments made by Prof. Silvanus P Thompson, and circulated amongst the shareholders, the Chairman stated that the directors had tested the phonopore, and were now of opinion that they had got an instrument which would meet the requirements of the market, and they hoped, therefore, that the position of the Company would be better in the future than it had been in the past. There could be no doubt whatever that in order to keep the Company in a proper position fresh capital would have to be raised in some form or other.

Mr. A. W. Hart seconded the motion.

Mr. Langdon Davies moved as an amendment: "That the consideration of the report and accounts for the year 1893 be deferred to an adjourned meeting, to be held within a month, and that a committee of shareholders be appointed to join the Board in considering the report and general condition of the Company's affairs. The directors and the committee to make a joint report or separate reports, as they think fit."

Mr. Philbrick seconded the amendment, and after a long discussion, in the course of which **Prof. S. Thompson**, **Mr. Kesky**, **Mr. Spagnoletti**, and others took part, the amendment was put to the meeting and rejected, and the resolution for the adoption of the report carried by a majority.

INDO-EUROPEAN TELEGRAPH COMPANY, LIMITED.

The ordinary general meeting was held last week at Winchester House, Major-General G. B. Tremenheere presiding.

In moving the adoption of the report and accounts, the **Chairman** said that the Company had had a prosperous year, having realised by way of revenue £5,380 more than in 1892. The expenses, however, had been slightly in excess. After placing £10,000 to reserve the Board recommended the payment of a dividend and bonus of 10 per cent. for the past year, carrying £6,452 forward. The work on the Company's system and on the other lines in connection therewith had been carried on with the most perfect regularity, and the average time of the messages had been eminently satisfactory. As a mark of their appreciation of the services of the staff, the Board had decided to set aside £4,000 for them from revenue by way of bonus, thus celebrating the completion of the first 25 years of the existence of the Company. He thought he might congratulate the proprietors on the very sound position of the Company.

The report was adopted and the dividend and bonus recommended declared.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.

The forty-first ordinary meeting of this Company was held on Wednesday, Sir John Pender presiding.

The **Chairman**, in moving the adoption of the report, said the receipts of the half-year amounted to £96,261, as against £106,860 in the previous half-year, showing a decrease of £10,598, and as compared with the income of the corresponding half-year of 1892, when it was £115,893, the decrease was £17,750. They had placed £20,000 to the reserve fund, which now stood at a very large figure; but he thought they were only right in carrying forward such a large amount, as they had never been able to find out the age of a cable, although they were keeping them in the same satisfactory condition. Continuing, he said their concession expired with the Brazilian Government; but they had sent out an agent to renew, if possible, the agreement for the next 20 years. The Government was undergoing a change, and they hoped that when the civil war was over a Government would be established, and with that prosperity would come. They had, moreover, obtained the power to lay a cable between Brazil and the Argentine, by which they would be able to compete with the American company. In conclusion, he thought the coming half-year would be one of some considerable interest.

The **Hon. W. St. John Brodrick**, **M.P.**, seconded the motion, which was adopted.

BUSINESS NOTES.

Foreign Office.—The Foreign Office is to be lighted by electricity.

Newark.—The Corporation is to be asked to establish a supply of electricity.

Ormskirk.—An electric organ has been dedicated in Ormskirk Church by Archdeacon Clarke.

Western and Brazilian Telegraph Company.—The receipts for the week ended April 27 were £2,825.

Prices of Dynamos.—The Governors of the University College at Bristol ask for prices of dynamos and motors.

Liverpool Overhead Railway.—The traffic receipts of this railway for the week ending 29th ult. amounted to £667.

Islington.—The seal of the Vestry has been attached to the conveyance of the site for the electric lighting station at Holloway.

York.—It is intended to adopt the high-tension system, and the surveyor to the Town Council is to report on the tenders of four firms.

Personal.—Mr. T. H. Parker, the son of Mr. T. Parker, has commenced business at Stourbridge as a consulting electrical engineer.

Cuba Submarine Telegraph Company.—For the month of April the receipts were £46 less than for the corresponding period of 1893.

Eastern Telegraph Company.—The receipts for the month of April were £56,751, as against £56,469 for the corresponding period of 1893.

Southampton.—A committee of the Town Council is considering the question of acquiring the undertaking of the local electric light company.

Kensington.—The Vestry have authorised the Notting Hill Electric Lighting Company to proceed with the extension of mains in Holland-park.

Dublin.—The Town Council have accepted, at £8,050, the tender of Messrs. J. Fowler and Co., Limited, of Leeds, for extensions of the electric lighting plant.

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Kingston.—Extensions in the plant are to be made, and for this purpose it is proposed to borrow £6,000.

Folkestone.—Another meeting has been held at the Town Hall to protest against the introduction of the electric light. The proceedings were very noisy.

Eastern Extension Telegraph Company.—For the month of April the receipts show a decrease of £2,911 as compared with the corresponding period of 1893.

Basingstoke.—The Town Council are about to employ an electrical engineer, at a fee not exceeding 20 guineas, to report on the cost of public lighting by electricity.

Baslow.—It is probable that the buildings of the Baslow Hydropathic Company, Limited, will be lighted by electricity. The directors are considering the matter.

Appointment Open.—As mentioned in our last issue, the Corporation of Sunderland invite applications by the 12th inst. for the position of municipal electrical engineer.

Sunderland.—It is expected that public electric lighting will be commenced at the end of the year. Prof. Kennedy is to prepare a report on the number of lamps to be erected.

Consolidated Telephone Construction and Maintenance Company.—The directors recommend a dividend at the rate of £2 per cent. per annum, less tax, for the year ending March 31.

Stock Exchange Quotation.—An application has been made to the Stock Exchange Committee to appoint a special settling day in, and to grant a quotation to, the shares of the Waterloo and City Railway Company.

Lighting of Ironworks.—The Lillieshall Company, Limited, are about to instal the electric light at one of their extensive works—namely, at the Snedshill Ironworks and Rolling Mills near Oakengates, Shropshire.

Burton-on-Trent.—Dr. Mason has decided to adopt the electric light for his new house and museum. The contract for the installation has been placed in the hands of Messrs. W. J. Furse and Co., electrical engineers, of Nottingham.

New Works.—The Hayesmoore Company inform us that they have opened works for the manufacture of electrical specialities at 10, Union-mews, Union-street, W. The head office of the company remains at 53, Crewsdon-road, Clapham-road, S.W.

Sale by Auction.—On Wednesday next, Mr. J. C. Stevens will sell by auction at 38, King-street, Covent Garden, a large quantity of apparatus removed from the School of Electrical Engineering. Further particulars are given in our advertisement columns.

Gravesend.—The first house in this town to be lighted electrically is Canterbury House, the residence of Mr. Hubert Edmonds. He has carried out the installation himself. The dynamo, of his own make, is driven by an engine constructed by Messrs. Drysdale and Co., West-street, Gravesend.

City and South London Railway.—The receipts of the Company for the week ended April 29 were £901, against £792 for the same period last year, or an increase of £109. The total receipts for the first half-year of 1894 show an increase of £153 compared with those for the corresponding period of 1893.

West India and Panama Telegraph Company.—The report for the six months ended December 31 states that the revenue amounted to £34,265, against £38,358 for the corresponding half of 1892. The expenses were £22,602, against £25 155 A dividend of 9d. on the ordinary shares, absorbing £3,312, is recommended.

Mill-Lighting.—Messrs. Bennett and Druce, of Preston, have received instructions from Messrs. Tootal, Broadhurst, Lee, and Co., Limited, Bolton, to entirely reorganise the electric light installation at present erected in their extensive mills. The installation will have to be practically refitted throughout, and will be considerably extended.

Country Mansion Lighting.—Messrs. Drake and Gorham have been entrusted with the erection of an installation at Greenway House, the country residence of Mr. T. B Bolitho, M.P., with about 120 lights. In this case it has been considered necessary to arrange for a petroleum-engine to drive an E.C.C. shunt-wound dynamo to charge 53 D.P. accumulators.

Coventry.—At a meeting of the Town Council last week, Mr. James asked whether the Council contemplated taking any action against Mr. Graff Baker in respect to the repairs of the roads on the tramway lines. The Mayor said that the matter had been before the General Works Committee and adjourned for a month. The month had almost expired, and they would be obliged to take action.

Lancashire Rubber Company, Limited.—This Company has been registered with a capital of £70,000 in £5 shares. The object is to acquire the business of a rubber manufacturer now carried on by A. McDougal at Holland-street, Pendleton, Salford, under the style of the Lancashire Rubber Company, and to acquire certain letters patent relating to an improved process of waterproofing.

Sale of Materials.—As stated in our advertisement columns, Messrs. Welsby and Bousfield have received instructions from the Executive Committee of the late Industrial and Fine Arts Exhibition, St. Augustine's Bridge, Bristol, to sell by auction, on the site, on Thursday, the 10th inst, the materials of the industrial section of the exhibition buildings, together with the whole of the electrical fittings.

Edinburgh.—At a meeting of the Electric Lighting Committee of the Edinburgh Town Council, a remit has been made to the consulting and resident engineers to prepare and submit a report as to the capital and annual cost of, and the number of lamps necessary for, the electric lighting of George-street, St. Andrew-square, Charlotte-square, and streets leading into these thoroughfares from Princes-street.

Worcester.—At the meeting of the Watch Committee last week, the Mayor stated that Mr. Hadley had arranged to give them a piece of land which was needed for the turbines at the electric lighting works, on condition that the Council made up the bank and planted it with chestnut or mountain ash trees. It was stated that the committee hoped to be ready to supply the electric light by October.

Submarine Cables Trust.—The trustees of the Submarine Cables Trust report that the revenue for the year to April 15, including the balance of £80 brought from the previous accounts, amounted to £22,673. The expenses amounted to £1,301, and the payments on account of the coupons to £21,131, together £22,432, leaving £240 to be carried forward. There is no change in the investments of the Trust.

Electric Lighting in Leather Works.—The electric light has been adopted in the leather-dressing works of Messrs. E. Turney and Co., and Messrs. Bayley and Co., Nottingham, and in both cases the contracts for the installations have been placed in the hands of Messrs. W. J. Furse and Co., of that town, who have adopted the E.C.C. dynamo, the power being derived from a Tangyes horizontal steam-engine.

Church-Lighting.—Considerable alterations have been made in the electric lighting of St. Paul's Church, Knightsbridge. All the handsome pendants for lighting the nave are now fitted with 32-c.p. lamps, enclosed in ground-glass shades, and the large crucifix over the choir screen is illuminated by reflected light with good effect. This work has been carried out by Messrs. Allpress and Co., of 55, Victoria-street, Westminster.

Branding Bacon by Electricity.—Some time ago, Messrs. Allpress and Co., of 55, Victoria-street, S.W., suggested to the Wiltshire Bacon Curing Company that they should utilise the electric current during the daytime for heating electric branding-irons, which should be used in place of the old-fashioned brands. This suggestion was adopted, and the company are now branding their bacon by this new method, which has given general satisfaction.

Newcastle.—At a meeting of the Newcastle City Lighting Committee an application was considered from the gas company requesting payment of upwards of £200 for the half-year for lamps which have been discontinued in various parts of the city in consequence of the erection of electric lamps. The town clerk was instructed to write to the company intimating that the committee could not see their way to recommend the Council to pay the sum named.

Toxteth.—At a meeting last week of the Toxteth Board of Guardians, Mr. Jones moved the appointment of a committee to make preliminary enquiries into the advisability of adopting the electric light in the workhouse. Mr. Johnston remarked that their gas was now costing them £500 a year. They had a 12-h.p. steam-engine which did their laundry and other work during the day, and this engine might afterwards be used to work a dynamo. He supposed that unless there would be an actual saving the Board would not go in for electric lighting. The motion was carried.

City.—At the last sitting of the Commission of Sewers, Mr. Ross, reporting on the number and cost of the gas lamps displaced by the arc lamps in the main thoroughfares, said the electric lights, numbering 479 arc lamps, cost £12,454 per annum, whereas the 1,315 gas lamps cost for lighting and maintenance £4,631 per annum. Mr. McCarthy, commenting upon the enormous increase, asked whether the Commission intended lighting the side streets by electricity, which would cost another £10,000 a year. Mr. Burmester said the Streets Committee was considering that point. The subject then dropped.

Belfast.—The Gas Committee of the Town Council have transferred £10,000 from the gas fund to the electric light fund to put the Electric Committee in a position to pay their present outlay. The Electric Committee report that Messrs. Scott and Sillars, contractors for the road work, have made considerable progress with the opening up of the streets and formation of the culverts. The laying of the mains in the compulsory area by the Corporation workmen is also being proceeded with. Mr. M'Cowen entered upon his duties as resident electrical engineer on the 26th ult., and is superintending the execution of the works under the direction of Prof. Kennedy.

Derby.—The Local Government Board have sanctioned the borrowing of £5,000 for the extensions of the electric lighting of Derby, repayable in 20 years. Between October 10 and March 31 the amount due from customers for electrical energy was £474. 7s. 10d., and the estimated amount due for street-lighting was £505. 15s. It is intended to supply the electric light to the two police stations and the market hall. The Art Gallery Committee of the Town Council have requested the Council to grant a further sum of £29. 3s. 1d. for wiring and fittings for the electric light, being the amount certified by the engineers (Messrs. Bramwell and Harris) to be due to Messrs. Paterson and Cooper for extras. The Council granted £109. 6s 4d. on September 6. The report has been accepted.

Buckingham.—The Lighting Committee of the Town Council have considered the letters sent in by the gas company and the electric light company. The former still adhered to their price of 4s. 6d. per 1,000ft., which could in no way be entertained, seeing that the agreement with the electric light company had been made—and the lamps, which are situate in and adjacent to the Market-square, have been fitted and lighted with

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the new illuminant. The electric light company in their letter referred to the shortness of time they were allowed in which to send in a tender for the lighting of the remaining lamps, numbering about 80, and scattered as they are all over the town. The committee recommended that further time should be given to the proprietors, Messrs. Parr and Gillies, and this was adopted without the slightest dissent by the Council.

Guildford.—At a meeting of the Urban Sanitary Authority the Town Clerk stated that he had received a letter from the Board of Trade saying that Sir Thomas Blomfield would be glad if the town clerk would call on him at his office at an early date with reference to the question of the electric lighting. It was decided that he should do so. The members of the Authority acting on the Fire Brigade Committee reported that they had given consideration to the proposal made to establish a system of call bells connected with the firemen's residences at an estimated charge of £22 per annum, and they had also received a proposal for connecting the police station and Mr. Heard's stables by a private wire at an estimated cost of £3 per annum, but the committee did not at the present time recommend the Authority to take any action with regard to either proposal. The report was adopted.

South Staffordshire Tramways.—In the Chancery Division on Wednesday the petition of Mr. Alfrew Dawson and other shareholders for the winding up of the South Staffordshire Tramways Company, Limited, came on for hearing. Mr. Herbert Reed, Q.C., in support of the petition, said the company had paid no dividends since 1887, and in April, 1893, a debenture-holders' action was commenced, under which receivers and managers were appointed, consisting of Mr. Sully and the chairman of the company, Mr. Wain. The petitioners attributed the condition of the company to a contract entered into by the directors with the Electric Construction Company. Mr. Buckley, Q.C., for the company, contended that this contract was very favourable to the tramway company, and, the charges made against the directors having failed, the petition ought to be dismissed. The hearing of case was adjourned.

Bradford.—The Gas and Electricity Supply Committee of the Bradford Corporation have decided that the scheme for supplying the electric light to the out-townships, Frizinghall, Allerton, and Heaton, should be pushed on without delay. A deputation has been appointed to visit the Halifax electricity works to inspect the process in use there for generating electricity in connection with the defæcation apparatus, the idea being that the power necessary for the sewage defæcation works at Frizinghall should be similarly utilised. A suggestion was made that circulars should be issued to ascertain how many of the residents in the townships named would be disposed to avail themselves of the supply, but many members thought it best to leave the matter alone for the present. It was also suggested that applications for the supply of electric light from the present works in Canal-road should be invited from residents and business people in Barkerend-road and Great Horton-road, but no action was taken. Plans are being prepared for the Frizinghall station.

Fareham.—A public meeting of the ratepayers has been held to consider the question of entertaining an offer of the Fareham Electric Lighting Company to sell the business and undertaking of the company to the Local Board. The Rev. T. G. Browne, who occupied the chair, read the letter sent by the company, offering to sell their works to the Local Board. Captain Ramsay proposed that the offer of the electric light company to sell their works by valuation be accepted, this being seconded by Mr. H. Plummer. Mr. Porter moved an amendment to the effect that the Local Board abandon their offer to purchase the electric light plant. He criticised very severely the several balance-sheets issued by the company, and described the whole concern as being valueless. He stated that out of £4,155 of subscribed share capital, £1,785 in shares, or three-sevenths of the whole, were held by Mr. Blake's family. Mr. Abraham seconded. The Chairman then put the amendment, in favour of which there were about 80 hands raised, and about 15 against. He therefore declared the amendment carried. Mr. Blake then said that, as he noticed a number of juveniles had voted, he demanded a poll.

Lighting of Ipswich.—A resolution was moved by Mr. J. Pratt at a meeting of the Town Council last week that the Urban Sanitary Authority should apply for a provisional order. The plant to light the district suggested (2⅔ miles) would require approximately an expenditure of £9,036, exclusive of private fittings to houses. The estimated cost of maintenance was £1,842, and this, with £274 interest and repayment on a 25 years' loan, would make £2,116 total annual expenditure. The charge of 6d. per Board of Trade unit is equivalent to gas at 3s. per 1,000. If at this rate they obtained 80 consumers using 15 lamps each (say, 10 for shop and five for private house), the revenue would be £1,600. In street-lighting the cost of 50 arc lamps at £15 each would be about £750 per year. The total revenue would therefore be £2,350, or £234 more than the expenditure. He therefore hoped that the scheme would be free of cost to the ratepayers. Messrs. F. Suter and Co., electrical engineers, London, reporting on the estimate, congratulated Mr. Pratt upon the reliability of his estimate, adding that his plan would easily supply 2,000 lamps 16 c.p., or 4,000 of 8 c.p., which would leave a margin for any number of lights that might be required in the district for some years to come. They felt confident that the plant could be obtained for less than £9,000. Mr. Pratt supplemented the above statement with some further observations. Mr. W. A. Churchman seconded the motion. After some discussion, the resolution was agreed to. The following committee was appointed: the Mayor, the Deputy-Mayor, Alderman A. Wrinch, and Messrs. W. A. Churchman, H. W. Raffe, E Catchpole, and J. Pratt, with the same powers as other committees of the Corporation in regard to the expenditure of money up to £100.

African Transcontinental Telegraph Company.—The report from December 27, 1892, when the Company was incorporated, to March 31 last, reminds the shareholders that in anticipation of formation a confidential prospectus was issued December 7, 1892, inviting subscriptions for shares. It was then proposed to raise a capital of £400,000. but ultimately the Company was registered with a capital of £140,000 only, being the estimated cost of constructing the line of telegraph from Salisbury, in Mashonaland, *viâ* Lake Nyassa and Lake Tanganyika to Uganda. Subscriptions for a substantial sum were received, but before determining to proceed to allotment the directors obtained from Mr. Cecil Rhodes an agreement to subscribe for the balance of the share capital at par, as explained in the circular sent out on March 16, 1893. In pursuance of this agreement, as and when moneys have been required, shares have been applied for by, and allotted to, Mr. Rhodes. The directors decided to first construct the 400 miles of the line between Salisbury and Zomba, the seat of administration of the Nyassaland Protectorate, and work was commenced simultaneously from each of these places with a view to meeting at a point near Tete on the Zambesi River. In furtherance of this project, 200 miles of material were shipped to Beira for transmission to Salisbury. the remaining 200 miles of material being shipped to Chinde for transport to Chikwawa on the Shiré River, about 60 miles south-west of Zomba. The outbreak of the Matabele war prevented operations during the dry season in respect of the construction of the southern or Salisbury-Tete section, and by advices dated the end of February, the directors regret to learn that since the war little or nothing had been accomplished, the rivers having been in flood, and transport impracticable. In the northern section between Chikwawa and Tete, good progress has been made.

Bristol.—At a meeting of the Electrical Committee of the Town Council it was resolved, on the motion of Mr. Tryon, that the resident engineer be instructed to report on the cost of extending the mains for private supply to Clifton and Tyndall's Park. On the motion of Mr. Bastow, North-street and Stokes-croft were added to the list, and, on the motion of Mr. Lloyd, Bedminster was also included. The report will not be ready for a month. The committee were informed that the new clocks and apparatus for ascertaining the current consumed in the daytime will be shortly put in hand, and that the patentee (Mr. Gisbert Kapp) had arranged with Messrs. Kemp Bros., of Union-street, Bristol, for the manufacture of the clock and apparatus on his behalf. The committee determined (subject to the application for the £24,000 loan being sanctioned) to extend their mains to Redcliff-hill at a cost of £855. Distributing mains will shortly be laid between Phippen-street and Bedminster Bridge, a number of applications for the light having already been received, including one for Redcliff Church, which it is intended to light throughout with electricity. A Local Government Board enquiry has been held to consider an application by the Town Council to borrow £42,000, of which £24,000 is required for electric lighting. In connection with the latter, Mr. Preece gave details of the expenditure already made and the projected expenditure on the new works. He mentioned that the excess of expenditure was not due to any error in the original estimate, but to extraordinary difficulties that arose in erecting the building. In preparing for the foundations of the structure they came across ground that had been made, and could not be utilised without being piled. Piling and constructing a retaining wall cost nearly £10,000. The original estimate for the building was £5,000; but subsequently applications for installations more than were anticipated came in, which led the committee to have a larger building erected and more plant placed therein, which brought up the cost to £13,000. The result was that Bristol had the best central electric lighting station in the kingdom so far as the structure was concerned. It was intended to expend about £15,000 more capital on new works to meet increasing wants. One extension had already been sanctioned, and another extension was under consideration.

Lighting at Chelmsford.—The Town Council last week received a letter from Messrs. Crompton and Co., calling attention to the manner in which the Council had treated their repeated requests for a better water supply. The matter was referred to the Sanitary Committee. The Town Clerk reported at the same meeting that he had received from the Board of Trade the draft provisional order for electric lighting in the form in which they proposed to issue it. It was proposed by the Council to insert that the purchase be limited to all such parts of Messrs. Crompton's undertaking as were used solely for the public and private lighting of the borough. The order, as settled by the Board of Trade, however, simply provided that Messrs. Crompton and Co. should sell to the local authority the undertaking authorised by the order, with all lands, buildings, materials, and plant used in connection therewith. He (the town clerk) had since, in a correspondence with the Board of Trade, pointed out the reason of the Council in wishing to have the undertaking defined more specifically, and he had also had a long interview with Sir Thomas Blomfield at the office of the Board of Trade on the matter. Sir Thomas Blomfield said they could not put in the words suggested, because it would be limiting the purchase to the public and private lighting of the town, and that if the Council purchased the undertaking they must purchase all such parts of the plant and material and so on as should be necessary for supplying energy within the whole of the borough, whether used for the public or private lighting of the town or for other purposes. He further said that the word "undertaking" did not comprise, and could not be held to comprise, any portion of

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Messrs. Crompton's business except such portions as should be necessary for the supply of energy within the borough. The same difficulty had arisen at Liverpool and Reading, and had been settled by the insertion of words which it was now proposed to insert in the Chelmsford order. Alderman Chancellor said the alteration meant that they would have to pay compensation to Messrs. Crompton and Co. for withdrawing their private business from these premises if ever they wished to purchase the undertaking. The purchase clause would be absolutely prohibitive. Alderman Brown thought, on the other hand, that the Board of Trade had protected the interests of the Council further than they had protected themselves. He thought Mr. Chancellor was decidedly wrong in his interpretation of the matter. Mr. Britton, chairman of the Lighting Committee, was of the same opinion as Alderman Brown. Mr. Whitmore said he could not see any great difference between the two clauses, excepting that the clause suggested by the Board of Trade gave the Council an advantage. They only asked for power to purchase the business as far as the public and private lighting was concerned, but by the alteration they would have power to purchase the whole of the energy, whether it was for cooking, or for warming, or for driving a tramway through the town. Therefore, he thought they were placed in a better position by it. After further discussion, it was agreed to leave the final settlement of the form of the order in the hands of the Board of Trade.

PROVISIONAL PATENTS, 1894.

APRIL 23.

7994. **An improved electrolytic trough or cell.** Ernest de Pass, 78, Fleet-street, London. (Hermann Thofehrn, France.)

7995. **Improvements in fittings for electric lamps.** Hugo Hirst, 73, St. Stephen's-road, Upton Park, London.

8007. **An automatic switch for telephones and other electrical apparatus.** George Lee Anders and Walther Kottgen, 31, Queen Victoria-street, London.

8011. **Improvements in appliances for increasing the duration of the top carbon of electric arc lamps.** Francis Jehl and Fritz von Hardtmuth, 28, Southampton-buildings, Chancery-lane, London.

APRIL 24.

8043. **An improved insulating cleat for supporting conducting wires for electrical circuits.** Horace Bartlett Wyman and Albert Clark Goodwin, 52, Chancery-lane, London. (Complete specification.)

8045. **Electric bell for application to bicycles, tricycles, and other cycles.** Woolf Goldberg Woolf, 160, Cassland-road, South Hackney, London.

8061. **Improved apparatus and process for electro-chemical decomposition.** Henry Carmichael, 55, Chancery-lane, London. (Complete specification.)

8115. **Improvements in apparatus for the manufacture, electrolytically, of tubes and other articles of circular section.** Francis Edward Elmore, 28, Southampton-buildings, Chancery-lane, London. (Complete specification.)

8125. **Improvements in dynamo-electric machines and electric motors.** Herbert Napier Prentice, 47, Lincoln's-inn-fields, London.

8149. **Improvements in electrical measuring instruments.** Henry Harris Lake, 45, Southampton-buildings, Chancery-lane, London. (John van Vleck and Edward Weston, United States.) (Complete specification.)

APRIL 25.

8215. **Automatic current distributor for multiple telegraphic transmission.** Ignace Bielski, 4, South-street, Finsbury, London.

8218. **Improvements in or connected with electric signalling or communicating apparatus.** Charles Stuart Jones and Henry Charles Collier, 4, South-street, Finsbury, London.

8224. **Improvements in electric lighting.** James George Willcox Aldridge, 40, Chancery-lane, London.

APRIL 26.

8238. **Improvements in electro-medical apparatus.** Augustus Basil Holt Clerke, 75, Church-road, Horfield, Bristol.

8240. **An improved ceiling rose for suspending electric pendant lamps.** Francis William Ball and John Hugh Winter, Bristol Bank-buildings, Bristol.

8273. **An improved form of shade tilt for electric light flexible-wire pendants or other similar fittings.** Ernest Alexander Claremont, Cooke-street, Hulme, Manchester. (Complete specification.)

8292. **Improvements in or relating to the charging of electrical accumulators or secondary batteries automatically.** John Evelyn Liardet, 9, Warwick-court, Gray's Inn, London.

8307. **Improvements in and connected with arc lamps and the regulation of the feeding of their carbons.** James Jamieson Fyfe, 41, Hillside.road, Stamford Hill, London.

8315. **Electrically-propelled tramway vehicles.** Walter Charles Bersey, 53, Chancery-lane, London.

8317. **Improvements in switches for use at central stations of telephone systems.** Henry Harris Lake, 45, Southampton-buildings, Chancery-lane, London. (The Antwerp Telephone and Electrical Works (Société Anonyme), Belgium.)

8328. **Improvements in electric condensers.** George Threlfall, 46, Lincoln's-inn-fields, London. (Richard Threlfall, Australia.)

APRIL 27.

8343. **An improved globe or shade holder for electric, gas, or other lamps.** George Frederick Sanders, 36, Temple-street, Birmingham.

8350. **Improvements in electric batteries.** Henry Harington Leigh, 22, Southampton-buildings, Chancery-lane, London. (Vohwinkel, Austria.)

8376. **Water-gauge with electric alarm for steam-boilers, water-towers, and reservoirs.** Heinrich Tommes and August Wellner, 5, Metzerstrasse, Cologne. (Complete specification.)

8412. **Improved method of and means for controlling electric currents.** Anthony Frazer, 1, Furnival-street, Holborn, London.

APRIL 28.

8443. **An improved arrangement of electrical contact surfaces for producing electrical effects in theatres, etc.** Alexander Fairley, 4, Boothroydon, Warley-road, Blackpool.

8478. **Improvements in electrically-propelled vehicles.** Ernest John Clubbe and Alfred William Southey, 53, Chancery-lane, London.

8480. **Improvements in and relating to galvanic batteries.** Thomas Henry Rushton, 115, Cannon-street, London.

SPECIFICATIONS PUBLISHED.

1893.

6751. **Extracting chromium by electrolysis.** Placet and Bonnet.

11176. **Electric bell, etc., indicators.** Gent and others.

12458. **Dynamo-electric machines.** Hutin and Leblanc.

1894.

3729. **Dynamo-electric machines.** Claremont.

4083. **Electric arc lamps.** Schleyder.

4144. **Electrodes for arc lamps.** Clark.

4539. **Joint for wires for electrical conductors.** Dieselhorst and others.

COMPANIES' STOCK AND SHARE LIST.

Name.	Paid.	Price Wednesday.
Birmingham Electric Supply Company	5	5½-5⅝
Bournemouth Electric Company	—	—
Brighton and Hove Company Original	100	210-215
Brush Company, Ordinary	3	2⅞-3
—— Nom. Cum., 6 per cent. Pref.	2	2⅛-2⅜
—— 4½ Debenture Stock	100	108-111
Charing Cross and Strand	5	4-5
Chatham and Rochester	—	—
Chelsea Electricity Company	—	—
City of London, Ordinary	10	12-13
—— 6 per cent. Cumulative Pref.	10	13½-13⅝
—— 5 per cent. Debenture Stock	75	82-85
City and South London Railway, Consolidated Ordinary	100	27-32
—— Debenture Stock	100	109-111
—— 5 per cent. Pref. Shares	10	10⅞-11½
Crompton and Co., 7 per cent. Cum. Pref. Shares	5	3½-3⅞
—— 5 per cent. First Mortgage Debentures—1-400 of £100 and A, 1-200 of £50	—	95-100
Elmore's French Company	3	⅛-⅜
Electric Construction, Limited	2	½-1
—— 7 per cent. Cumulative Pref.	2	1½-1¾
Elmore's Copper Depositing	2	½-¾
Electricity Supply Company for Spain	5	—
Elmore's Wire Company	2	½-¾
Fowler-Waring Cables	5	½-1½
House-to-House Company	5	½-1
India Rubber and Gutta Percha Works	10	23-24
—— 4½ per cent. Debentures	100	102-104
International Okonite, Ordinary	10	1-2
Kensington and Knightsbridge	5	4⅜-5½
Liverpool Electric Supply, Ordinary	5	6¼-6⅝
—— Pref.	4½	5⅞-6¼
Liverpool Overhead Railway	10	7½-7⅞
—— 4 per cent. Mortgage Debentures of £100	100	107-109
London Electric	5	½-1½
Metropolitan Electric Supply	10	7-7½
—— 5 per cent. Reg. Debentures, 1-10,000 in Bonds of £10, £20, and £40	—	106-109
National Telephone, Ordinary	5	4⅜-5
—— 6 per cent. Cum. First Pref.	10	15-16
—— 6 per cent. Cum. Second Pref.	10	14½-15½
—— 5 per cent. Nom. Cum. Third Pref.	5	5⅛-5⅜
—— 4½ per cent. Deb. Stock	—	115-117
Notting Hill Company	10	4½-6½
Oriental and Electric Company, £1 shares	11	⅜-½
Southampton Electric Company	—	—
St. James's and Pall Mall, Ordinary	5	6⅜-7½
—— 7 per cent. Pref.	5	8-8½
Swan United	3½	2-2½
Telegraph Construction and Maintenance	12	39-41
—— 5 per cent. Bonds	100	—
Westminster Electric Supply, Ordinary	5	5½-6½
Yorkshire House-to-House	4½	4½-4⅝

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NOTES.

"**Micamen**" should read note on "Continental Trades' Directory."

Calcutta.—The subject of introducing a public supply of electricity is in abeyance.

Biella.—The depôt of the local tramway company has now been electrically lighted.

The Latest.—A penny-in-the-slot electric boot-cleaning machine. We should like to see it.

Madras.—The laying down of the permanent way of the electric tramway is progressing.

Novara.—The central station for the supply of electric light has just been set in operation.

Rating of Machinery.—The Rating of Machinery Bill passed the second reading on Wednesday.

Dr. Herz.—The proceedings against Dr. Herz have been abandoned. He will now possess a happy *herz.*

Telephony in India.—Telephonic communication between different offices at railway stations is being established.

Dresden.—Arrangements have been made to construct a central electric light station on the site of the gasworks in the Stiftstrasse.

Train-Lighting.—The North-Western Railway Company of India are considering the question of lighting their trains by electricity.

Society of Chemical Industry.—A paper on "The Commercial Electrolysis of Fused Salts," by Mr. Claude Vautin, was read on Monday before this society.

Personal.—Mr. C. Ashmore Baker, A.I.E.E., has established himself at 28, John-street, Bedford-row, W.C. where he will carry on his business of consulting electrical engineer.

Cable Extension.—The laying of the second section of the alternative Singapore-Hong-Kong cable—namely, that between Labuan and Hong-Kong—has now been completed, and the line opened for traffic.

The Industrial Exhibition.—Among the exhibitors at the Industrial Exhibition now open at Earl's Court is the Brush Electrical Engineering Company. It is proposed to establish electric fountains in the grounds.

Klausenburg.—The local authorities of this Transylvanian town have decided to introduce the electric light. The concession has been given to Herr Josef Körner, a local merchant. Work has been commenced.

Students of the Institution.—A students' meeting of the Institution of Electrical Engineers will take place on Friday next, the 18th inst., at 28, Victoria-street. A paper by Mr. P. W. Paget, entitled "Notes on Gas-engines," will be read.

Time Indicator for Railways.—Mr. Ludwig Kohlfürst describes in the *Elektrotechnische Zeitschrift* of May 3 a system of electrically transmitting time to railway station clocks. The system is in use on the lines of the Imperial Railway Administration in Berlin.

Dynamos and Transformer Construction.—Mr. James Swinburne, M.I.E.E., will commence, on the 29th inst., a course of lectures on this subject to the students of the Electrical Standardising, Testing, and Training Institution, Faraday House, Charing Cross-road.

Cheap Telephony.—Mr. Henniker Heaton, it is said, looks forward to the time when every private house in England will be supplied with a telephone service for £3 a year, and when it will be possible to speak with America and Australia. Mr. Heaton is certainly very sanguine.

Saint-Quentin.—The gasworks have had to commence operations for the supply of electricity according to their contract. Gas motors of 70 h.p. will be employed driving continuous-current dynamos. The three-wire system is to be adopted. The tariff price is 16 centimes per hectowatt-hour.

Bournemouth.—We understand that on Monday evening the engines at the electric light works had to be stopped, and that there was a cessation in the supply of light. There was, it appears, a great noise set up in the telephone wires. On Tuesday the supply was resumed to some of the consumers.

Utilisation of Atmospheric Electricity. — A scheme has been presented in all seriousness to the French Academy of Sciences for the revolution of industry! It is nothing more or less than the old-fangled notion of extracting electricity from the atmosphere and using it for lighting and other purposes.

Telephony in Italy. — The Italian Telephone Administration some time ago granted a number of concessions for working telephone exchanges. Our contemporary *L'Elettricità*, in its issue of May 6, gives a table of the towns having telephonic facilities, the number of subscribers, annual rentals, etc.

Exhibition at Bucharest.—The co-operators of Roumania propose to hold their fourth exhibition at Bucharest this year, to commence on August 26 and to close on November 12. In order to encourage foreign manufacturers to take part in the exhibition, space is to be set apart for an international section.

Temesvar.—The municipal electric lighting station, which is the only municipal electric plant in Hungary, made a profit of 22,000 florins on its last year's working. In consequence thereof, the price for current has been lowered to 1·8 kreuzers per lamp-hour, and large consumers will be given a rebate up to 15 per cent.

Tramway Traction in France.—The Compagnie Générale Francaise de Tramways, whose annual meeting takes place on the 21st inst. at 60, Rue de la Chaussée d'Antin, Paris, states that they have been compelled to substitute mechanical (electrical) traction for horse haulage at Havre, Marseilles, Nancy, and Genoa.

Legislation in Italy.—The development of electrical engineering in Italy has induced Mr. Boselli, the Minister of Commerce, to introduce a Bill for regulating the long-distance transmission of energy and its distribution for industrial purposes. The details of the proposed legislation are set forth by Mr. A. Banti in *L'Elettricità* of April 22.

Dublin.—Mr. M. Ruddle, the electrical superintendent of the Dublin central station, has written a letter to the *Freeman's Journal* to correct certain statements made by the latter in regard to danger and inconvenience alleged to have been caused on the occasion of a fire in Henry-street, when a circuit was broken through the fall of a wall on to a street arc lamp.

Cork Telephones.—Under a new regulation of the National Telephone Company, subscribers availing of the "unlimit" (£10 and over) system can communicate with Queenstown and Midleton without extra charge; £5 subscribers are asked to pay 3d. for three minutes or any fraction thereof. Hitherto there was a general charge of 6d. for five minutes' communication with Midleton and Queenstown.

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Lithanode Cells.—Recent improvements introduced in the manufacture of lithanode have tended to reduce the cost, and the Lithanode and General Electric Company, Limited, have therefore decided to considerably reduce the price of their electric lighting and other lithanode cells. The company's reduced price list shows that their prices compare favourably with those of any other makers of secondary batteries in this country.

A Question of Failures.—It is rather a one-sided affair for the Bath Electric Lighting Company, or, for that matter, any other company supplying the electric light, to be mulcted in fines for failures when the local gas company is allowed to be free from such onus. At all events, the Bath Electric Light Company have the satisfaction of knowing that all their dirt is washed entirely away, even if the gas company does not get a clean bath.

A Goak.—A correspondent sends us the following clipping from *Pearson's Weekly* of May 12, 1894: "Mica is chiefly made use of for dynamos, electric alternators, and transformers, and also for placing at the ends of cables for the purpose of absorbing the electricity which lingers in the wire after a message has been sent, the presence of which would affect subsequent messages." Surely a little knowledge is a dangerous thing if this information is seriously given.

Might Very Well Be.—Ordinary young man, to learned professor: "What you say, then, is that the brilliant aurora borealis and other such fireworks of Nature are all brought about by electricity?" Professor: "Yes; these phenomena are undoubtedly electrical." Young man: "Well, now, I wonder if they are a sort of reservoir for all the bad language used through the telephone?" Perhaps Mr. Preece may have a desire to be heard upon the subject.

A Long Electric Railway.—The construction has been commenced of the Chicago and St. Louis Electric Railway. Dr. Wellington Adams, the promoter of the line, has been perfecting his plans and arranging to raise money. It is now said there is no longer any doubt about the line being pushed through to completion. It is said the General Electric Company has no hesitation in guaranteeing that it can build high-speed motors capable of travelling 100 miles an hour with perfect safety.

Bozen.—Herr Oscar von Miller has explained to the Municipal Lighting Committee of Bozen the project for the electric lighting and power transmission installation for Bozen and Meran. He recommends that a generating station should be established on the Töll above Meran. Current would be taken to Bozen by means of overhead conductors. The estimated cost for a joint scheme for the two towns is £71,600 for 2,000 h.p., £88,400 for 3,000 h.p., and £114,800 for 6,000 h.p.

Coventry.—Mr. F. H. Tulloch, Local Government Board inspector, held an enquiry on Wednesday into the proposal of the City Council to borrow £20,000 for the purposes of electric lighting. The Town Clerk stated that powers were given to the Corporation to light the city with electricity in 1891, and they were required to light certain streets within a certain time, and it was proposed to do that at once out of the loan now asked for. The charge was to be 8d. per Board of Trade unit.

Royal Meteorological Society.—An ordinary meeting of this society will be held at 25, Great George-street, Westminster, on Wednesday next, at 8 p.m. Papers on the following will be read: "The Relative Frequency of Different Velocities of Wind," by Mr. William Ellis, F.R.S.; "Audibility of 'Big Ben' at West Norwood Under Certain Meteorological Conditions," by Mr. William Marriott, F.R.Met.Soc.; and on "Earth Temperatures at Cronkbourne, Isle of Man, 1880-1889," by Mr. A. W. Moore, M.A.

Charing Cross-Hampstead Railway.—The London County Council on Tuesday approved of the withdrawal of the petition of the Council against the Bill promoted for the construction of this railway. The Unopposed Bill Committee of the House of Commons on Tuesday passed the Bill promoted by the Charing Cross, Euston, and Hampstead Railway Company. The object of the measure is to acquire additional lands for stations, etc., in the parishes of St. Martin's-in-the-Fields, St. Anne's, Soho, St. Giles-in-the-Fields, and St. Pancras.

The Heilmann Locomotive.—This locomotive, to which we have referred on previous occasions, was tested on Wednesday on the Western of France Railway. The locomotive drew a special train from the St. Lazare Terminus in Paris to the Seine et Oise Station, a distance of 33 miles, performing the journey in 55 minutes. The train was composed of five coaches and a dynamometric brake van, and at certain portions of the line a speed of 65 miles an hour was attained. The locomotive subsequently took the ordinary train, No. 54, back to Paris.

The "Medical Battery" Company.—An application has been made to Mr. Justice Williams to allow the debenture-holders' receiver for the "Medical Battery" Company, Limited, to continue to sell the Harness "electric" belt. His Lordship said he was loth to allow an officer of the court to continue to sell these goods by such methods as had previously been resorted to. Counsel for the receiver assured his Lordship that the sale was being carried on without any false representation or guarantee being given as to efficacy. The carrying on of the business for a further two months has been granted to realise the assets.

Buxton and Chesterfield.—The Electric Lighting Provisional Orders Bill (No. 1) has been before Mr. Thomas, the examiner of the House of Commons, for proof of compliance with Standing Orders. The object of the Bill is to confirm certain provisional orders made by the Board of Trade to enable, among other local authorities, the Buxton Local Board and the Corporation of Chesterfield to use electricity under the Electric Lighting Acts of 1882 and 1888. Formal proof having been given, the examiner decided that the Standing Orders had been complied with, and the Bill will in due course be reported for second reading.

Laying of New Mains.—The Kensington and Knightsbridge Electric Lighting Company intend to lay additional mains in Brompton-road, and to lay mains on both sides of Beauchamp-place. Messrs. Siemens Bros. and Co., on behalf of the Hampstead Vestry, are about to lay underground cables and to construct underground transformer-chambers in Finchley-road; and the St. James and Pall Mall Electric Light Company intend to lay new feeder and distributing mains in New and Old Burlington streets, Burlington-gardens, Regent-street, Cork-street, Vigo-street, Glasshouse-street, Brewer-street, Air-street, Piccadilly, Great Windmill-street, and Wardour-street.

Telegraphists of the Late Submarine Cable Company.—Mr. A. Morley, in answer to a question in the House of Commons on Monday, said the last memorial from the officers who were in the employ of the late Submarine Telegraph Company, asking that their period of service with the company should be recognised towards their pension was dated October 23 last, and it was answered on the 10th of the following month. The subject had, on more than one occasion, been considered by the

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Treasury, and the officers in question were aware not only of the steps which had been taken to deal with their representatives, but also with the result.

Continental Trades' Directory.—Some correspondents ask us to give the name of the publication which takes on the Continent the position occupied by "Berly's Electrical Trades Directory" in England. For their benefit, and that of other firms, we have investigated the matter, and believe that the following directory will meet every requirement: the "Adressbuch der Elektricitäts-branche und der damit verwandten Geschaftszweige." It is published in two parts. The first refers to Germany alone, and the second to the whole of Europe. Either part may be obtained separately. The publishers are Messrs. Eisenschmidt and Schultze, of Leipsig.

Dr. K. E. Zetzsche.—The death is announced of Dr. K. E. Zetzsche, the electrician. He was born at Altenburg in 1830, and studied at the Dresden and Vienna Polytechnics. In 1856 he entered the Austrian telegraph service, and worked in Vienna, Padua, and Trieste. In 1858 he taught mechanics and mathematics at a technical college in Chemnitz, and in 1876 became professor of telegraphy at the Dresden Polytechnic. He was one of the chief contributors to the "Handbook of Electrical Telegraphy," published in Germany, and wrote various other books, besides being a contributor to a number of technical papers. He was likewise the inventor of some electrical apparatus.

The Hermite System.—An analysis of the reports on the Hermite system by Dr. Kelly and Dr. Piton, and to which we referred in previous issues, was given in the *Standard* of Monday's date. That paper concludes with the following pertinent remarks: "Before the Worthing authorities decide against the Hermite system, it would be well that a series of experiments similar to those of Dr. Piton should be carried out. Certainly a question of such vast and far-reaching importance, not only to the town of Worthing but to many other places, ought not to be decided either for or against from the results of chemical and bacteriological investigation of one or two samples. It may well be that Dr. Kelly has arrived at his conclusion too easily and too hastily; and the question is of such importance that it deserves to be definitely settled one way or the other."

Lighting of Mail Coaches.—We have, in previous issues, referred to the successful results attending the experiments made in Germany in the direction of lighting mail coaches by electricity. We now learn that the German Postmaster-General has ordered 42 new mail coaches for the night express trains. These coaches are to be electrically lighted, and Boese accumulators are to be used for this purpose. These accumulators have been in use for train-lighting for the last 12 months, and the result has been so satisfactory that the German Post Office has now decided not only to adopt Boese accumulators for all new mail coaches, but also for the old ones now undergoing repair, thus replacing the gas. Consequent upon the German Government's experience the Austrian State Railway Administration has also adopted this type of battery for train-lighting. The International Electric Company, of 55, Redcross-street, who are the sole agents for the United Kingdom and the colonies for the Boese accumulator, have during the past few months had a large sale for the battery, and the demand is daily increasing.

Tramway Congress at Cologne.—It appears from the preliminary programme issued by the Union Internationale Permanente de Tramways, that the union intends to have a grand time at the eighth general meeting to be held at Cologne in August next. The sittings of the congress will extend over eight days—probably in view of the fact that the gathering will be the eighth of the kind. The first assembly will take place at 8 p.m. on Saturday, August 18, when the members will be received at the Güzenich. On the following day an excursion will be made to Remscheid and to Barmen-Elberfeld, where the rack electric railway will be inspected. On Monday, August 20, the first general meeting will take place in the Isabel Hall at the Güzenich. On Friday, August 24, the members will be divided into two groups, one of which will visit the well-known Hoerde Steelworks and the Dortmund electric tramway, whilst the second group will inspect the Phœnix Steelworks at Laar, near Ruhrort, and the Essen electric tramway. On Saturday, August 25, the members will start for Antwerp to view the international exhibition there.

Working Instructions.—A neat and handy little volume has been issued by the Brush Electrical Engineering Company, Limited. It is entitled "Instructions for Working Plant," dealing with Brush plant, and should be found very useful by those who have the charge of such machinery. The first section deals with Mordey-Victoria alternators and transformers. A description, brief and to the point, is given of the Mordey-Victoria alternate-current system, with a diagram, and a description of the machines also appears. Then we have an account of the Brush-Vienna dynamos and motors; of the Victoria dynamos and motors; Brush dynamos and Brush-Geipel regulators; of the Brush arc lamps, direct current, series or parallel; of the Brush-Vienna arc lamp, direct or alternating current; and of engines and boilers supplied by the company. The instructions show how to fix, explain the lubrication of the machines, draw attention to the necessity for cleanliness, and generally give useful and practical information to the men employed in the machinery-house of a Brush installation. The little book should be productive of efficiency and economy in the running of stations.

Lighting of the Embankment and Bridges.—It will be remembered that on the 10th ult. the London County Council instructed the Highways Committee to consider and report on the feasibility of providing for the lighting of Westminster and Waterloo bridges by electricity apart from the question of similarly lighting the Victoria-embankment. On May 1 a petition on the subject from the North Lambeth Liberal and Radical Club was referred to that committee. Having given careful attention to this matter, the committee have come to the conclusion that, in view of the very large extra expense that the establishment of a separate installation for the two bridges would involve, it is not advisable that the course indicated in the resolution of the Council should be adopted. The committee reported further that the drawings for the generating station are approaching completion, and it is anticipated that the installation will be completed in time for the embankment and the bridges to be lighted by electricity next winter. They had still under consideration the question of the positions in which the lamp standards for the embankment shall be placed; but in the meantime the other work can be proceeded with.

Constant-Speed and Series-Wound Motor.—Mr. G. Mariotti, writing in the *Elektrotechnische Zeitschrift*, says that series-wound motors are preferable to shunt or compound wound motors wherever the load is not subject to wide variations. If, however, the load on a series-wound motor be liable to considerable reduction, there is danger of the motor racing, and then the shunt motor, or one with compound winding on the field magnets, is preferable. The author describes a method of exciting a series-wound motor,

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under which the speed for all loads remains approximately constant. The method consists in supplementing the exciting current by means of a small over-compounded dynamo driven by the motor. The terminals of the auxiliary dynamo are coupled to the terminals of the field coil of the motor, and the characteristic of the dynamo is so chosen as to increase the auxiliary current when the load on the motor decreases, thereby strengthening the motor field and keeping the speed of the motor within the desired limit. To prevent reversal of polarity, due to overloading, an automatic magnetic cut-out is employed. The author gives the theory of this apparatus by means of various diagrams, and refers to a practical application of his method on a 14-h.p. motor, working on a 500-volt circuit. The output of the auxiliary dynamo in this case is 400 watts.

Energy, Current, and Candle-Power of Arc Lamps.—Mr. Frank B. Widmayer, in the New York *Electrical Engineer*, gives the following table, which shows the current required for arc lamps of the various systems of arc lighting with constant current, which will be found quite useful in an electrical repair shop, where lamps are sent in to be repaired and then readjusted. The table gives the normal current of the various systems and the so-called (trade) candle-power of the same:

Table I.—Currents in Amperes.

System.	800 c.p.	1000	1200	1600	2000	3000	4000
Ball	4·	—	6·&6·4	8	10·	15·	—
Edison (Sperry)	—	—	6·4	—	10·	—	—
Easton	—	—	6·	8·	10·	—	—
Brush	—	—	6·4	—	9·6	15·	20
Thomson-Houston	—	5·	6·8	—	10·	15·	—
Western Electric	—	—	—	—	9·6	—	—
Clark	—	—	—	—	9·8	—	—
Schuyler	—	—	—	—	9·5	—	—
U. S. Old / Western Electric (low-tension)	—	—	—	—	18·	—	—
Excelsior	—	—	—	—	10·	—	—
New Wood or Ft. Wayne	4·2	—	6·8	—	9·5	—	—

Table II.—Candle-Power.

So-called candle-power.	Watts per lamp.
2,000	450 to 500
1,600	384 to 416
1,200	278 to 310
800	200 to 226

The second table shows the number of watts consumed by lamps of various systems and their relation to the so-called candle-power; these results were obtained from a number of readings, and the averages are given in the tables.

Automatic Regulator for Dynamos.—We have received a circular referring to Conrady's automatic regulator for dynamos. The regulator comprises a solenoid, the core of which operates a reversing friction clutch to which power is supplied mechanically. The solenoid has only to put the friction clutch into or out of gear, and it therefore absorbs only a negligible amount of current, being from 5 to 30 watts. The power required for operating the regulating means being supplied from a separate source, may be made of any required amount without interfering with the prompt and accurate action of the regulator. This regulator may thus be adapted to operate either a variable resistance, or the brush-holder of a series dynamo, or the throttle-valve or expansion gear of the steam or other motor driving the dynamo, or any other means of regulation. This regulator is made by Messrs. Conrady and Co., of Keighley, the London agents of whom are the Indestructible Ignition Tube Syndicate, of 100c, Queen Victoria-street, E.C. This regulator is made to control all systems of electric supply. The principal cases are for constant-current supply, constant-potential supply, and supply by several dynamos working in parallel. It is claimed that these regulators will keep the dynamos controlled by them within 1 per cent. of the required normal condition (current or voltage). For ordinary work, regulators, either series or shunt wound, are furnished, and operating regulating resistances capable of absorbing up to 200 watts.

A Transmission Dynamometer.—Dr. Louis Duncan describes in the *Electrical World* a transmission dynamometer which has been found useful for some special experiments for a number of years. He says: "I have used an absorption dynamometer consisting of a copper disc rotating in a magnetic field. The power was calculated from the pull on the magnet and the speed of the disc. The heat was absorbed by water running through the apparatus. This dynamometer is of a rather limited range, unless belting is resorted to. For the purpose of trying some experiments on the efficiency of air propellers, a transmission dynamometer was designed on somewhat the same principle. It consisted of a copper disc fastened to the propeller to be rotated and placed in the field of a rotating electromagnet. The apparatus was calibrated by turning the magnet at known speeds and measuring the pull of the disc, which was kept stationary. After this, to measure the power transmitted, it is simply necessary to know the speeds of the field magnets and the copper disc, and the pull is proportional to the difference of the speeds, and can be obtained from the calibration curve. The disc is so constructed that it can be cooled by allowing water to flow on it in such a manner as not to absorb power, and a temperature correction can be applied if necessary. The speed of the disc can be regulated by varying the speed of the magnets and the strength of the magnetic field. In this way power can be transmitted without the intervention of any belt or gearing, and it forms an exceedingly convenient apparatus for some purposes."

Technical Education in London.—The Technical Education Board of the London County Council propose to hold, with a view to promoting a better understanding of the needs and desires of the various trades in the matter of technical education, during the months of June and July, a series of public conferences between the representatives of the principal London industries. It is hoped by a free and practical discussion among those actually concerned in industry to elicit useful information as to what kind of technical education is required in each case, in what way the existing provision is defective, how it can be rendered more efficient, and what steps can be taken to bring it to the notice of the young workman or the apprentice. Each conference will be strictly confined to representative practical men belonging to one particular group of trades. Every trade union belonging to the group will be asked to nominate delegates. Every employers association will be similarly invited. The London Chamber of Commerce and the London Trades Council will also be asked to designate other representative employers and workmen. The meetings will take place probably at the County Hall, Spring-gardens. The first meeting will be devoted to the building and furniture trades. The three subsequent meetings will follow at fortnightly intervals, and will deal respectively with the engineering, shipbuilding, and metal trades; the book, paper, and printing trades; and the clothing, leather, and miscellaneous trades. The names and addresses of representatives should be sent at once to the Secretary of the Technical Education Board, 13, Spring-gardens, S.W., from whom any further information can be obtained.

Submarine Telegraphy.—Our contemporary *Commerce* in its last issue says: "Much has yet to be done before the world can boast that it is served either as effectively or as cheaply as it ought to be in the way of cable communication. Particularly is this the case with outlying portions of our empire. Heartily glad are we to see that in South Africa, as in Australasia, the business

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men to whom the ocean lines are invaluable are pushing forward with an agitation for a cheaper, if not a better, cable service. The great initial expense of laying these submarine lines is, no doubt, a serious obstacle. But the conveniences they offer to individuals, as well as to Governments in times of peace, immense as they are, sink into insignificance compared with their value, if thoughtfully planned and laid, to any great Power in war time. On no country more than on our own is it incumbent to establish these adjuncts to the defensive forces; whilst the keen commercial rivalry of the industrial nations impels each to seek for and to use the speediest and most effective means of communication with their *clientèle*. In spite of the heavy costs incurred in the installation and in the maintenance of their lines, the Eastern Telegraph Company is able to distribute a very satisfactory dividend to its shareholders. Under the guidance of Sir John Pender—who, when he is the only Richmond in the field, knows better than most men how to drive a bargain—that company has been able to obtain much larger subventions from Governments than the future will permit. Present contracts have to be respected, but, at the Cape, the expiry five years hence of the arrangement with the Eastern Telegraph Company is eagerly awaited, when, as Sir Gordon Sprigg has declared, the Government will have the whip-hand of the company, instead of the company, as at present, having the whip-hand of the Government."

Three-Phase System in Austria.—A small central station on the three-phase system has recently been established at Erding, an Austrian town of some 3,000 inhabitants. The generating station is situated about two miles from the town, the motive power being obtained from the River Sempt. A horizontal turbine, supplied by the Augsburg Engineering Works, develops 60 h.p. at a speed of 35 revolutions, and by means of countershafting, pulleys, and belting two dynamos of nominally 40 kilowatts are driven at 750 revolutions. These alternators are direct coupled to the exciters. The exciting current is brought to the inductor by means of rings upon which the brushes press. The alternator produces a difference of potential of 1,500 volts, and a maximum current of 15 amperes in each circuit at a frequency of 50 periods per second; the exciter gives current at 60 volts. A single alternator absorbs the whole power of the turbine. Leaving the alternator, the current is led by means of three cables to the distributing-board. Passing from the station, the current is conveyed by three wires to Erding. Here the high-tension circuit feeds five transformers. The secondary circuits are connected in quantity, and form the distributing circuit. The conductors passing out of the generating station are of bare copper enclosed in glass tubes, and they are afterwards fixed to oil insulators carried on masts 40ft. high, of which there are 81, arranged at intervals of 130ft. Special arrangements have been adopted to prevent accidents from atmospheric changes. For instance, a metallic point in connection with the earth has been fixed at the top of 16 masts, being one in every five. A lightning protector has also been erected. It is formed of two carbon plates, one being a short distance from the other. The upper plate has an iron core movable in a solenoid. The wires of this solenoid lead respectively to the iron core on the one hand, and to the earth on the other. The second plate is connected to the conductors. If an atmospheric discharge takes place, an arc is set up between the two plates, and the circuit is closed through the earth. But as the iron core is attracted the arc is abruptly broken. Similar lightning conductors have been fixed in 15 parts of the secondary network. The streets are lighted by 97 16-c.p. lamps and six 12-ampere arc lamps, and altogether 600 lamps are supplied in the town, besides a few electric motors.

The Electrical Trade Section.—A meeting of some importance to the electric traction industry was held on Friday last at the London Chamber of Commerce, when the Electrical Trade Section was summoned to discuss the provisions of the Locomotive Acts in relation to electric conveyances. The chair was taken in the first instance by Mr. R. Percy Sellon, in the temporary absence of Major Flood-Page. The secretary of the Chamber, Mr. Kenric Murray, read a letter which had been received from the Chief Commissioner of Police regarding the position of the Metropolitan police authorities towards the use of omnibuses and similar conveyances on public streets worked by electric motors, and explained that some recent experiments with driving an electric postal van through the crowded City streets had provoked a letter to the *Times*, raising the question as to whether such vehicles do not come under the Locomotive Acts of 1861, *et seq.* In consequence of this letter, the Chamber had written to Scotland Yard for an official opinion upon the subject, and, in reply, were informed that counsel had advised the Chief Commissioner on the point, to the effect that all vehicles *driven by other than animal power* must be construed to come within the Act. Considerable discussion ensued upon this point, and various suggestions were made. Mr. Sydney Morse proposed that the Chamber should—with the kindly help of the Board of Trade — bring in a Bill to amend the Act so as to allow the use of electrically-driven conveyances on the streets. Mr. Trotter asked whether previous opinions from the police had not been the direct converse of those now stated. Mr. Sellon thought, in the first place, that the initiative of action might be left to those more particularly interested, and these were, he thought, at present very few. A test action might be brought, and the matter decided in court. Obviously, the question turned upon the definition of "locomotive" in the Acts, and equally obviously these, when framed, had never contemplated the use of electrically-propelled vehicles. Major Flood-Page assured the meeting that considerable advance in the development of electric traction on streets would take place within the next year or so, and it was therefore of great importance that the disputed point should be settled as soon as possible; also that the influence of the Chamber would be of service in obtaining a favourable issue. It was therefore resolved finally that a letter should be sent from the Chamber to the Board of Trade asking that Department to move in the matter to the extent of promoting an Act to amend those in question, leaving it at the same time to those persons more particularly interested in the development of electric traction on this plan to obtain an interim decision under the Acts—probably favourable—by means of a test case in the law courts. The remainder of the meeting was occupied with a brief discussion upon the rating of electrical works. Mr. Morse gave details of the excessive revaluations of conduits, pipes, and mains laid down in connection with central-station work, the base underlying such valuation being apparently that of the hypothetical tenant. In one case the excessive valuation meant a difference of 1 to 1½ per cent. in the dividend. It was resolved in the end to have an early meeting of the section, and then to appoint a special committee to deal with this matter. Meantime every effort is being made to secure, on behalf of electrical interests, the united action which will effect the desired result more quickly and readily than isolated objection.

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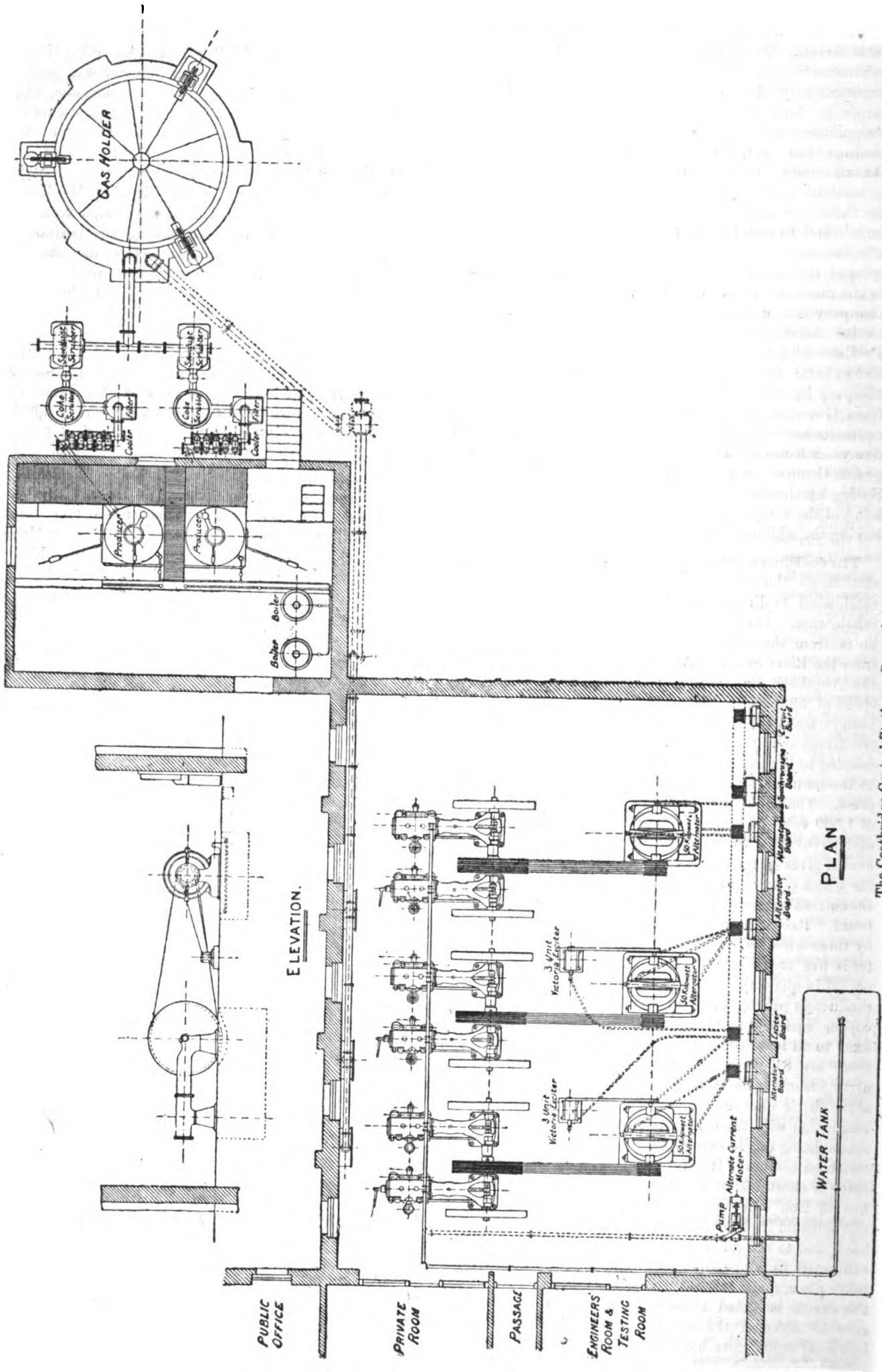

The Coatbridge Central Station.—General Arrangement o the Works

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THE COATBRIDGE CENTRAL STATION.

We give herewith an illustration which shows in plan and elevation the general arrangement of the Coatbridge central station of the Scottish House-to-House Electricity Company, Limited, and which has been equipped by the Brush Electrical Engineering Company, Limited. As a full description of this station was published in the *Electrical Engineer* of the 6th April, it will only now be necessary for us to refer our readers to that issue for the details of the plant and method of distribution.

THE STANSERHORN ELECTRIC RAILWAY.

This line, which was opened last August, has operated successfully for the intervening period; and details of its construction and working were lately brought forward before the Société des Ingénieurs Civils of France, to show the possibilities and advantages of such a system as that employed. The line was undertaken by Messrs. Bücherer and Dürrer—a firm of Swiss engineers—who also promoted and built the Bürgenstock and the Genoa tramways: and it has a number of interesting features which give it prominence amongt mountain railways. The Stanserhorn mountain rears itself to a height of nearly 6,000ft. from sea-level, being, therefore, a little higher than the Righi, but less than Mont Pilatus. The town of Stans is situated at its feet, and from the summit a magnificent view is obtained over the whole of the Bernese Alps, the lake of the Four Forest Cantons, and the northern parts of Switzerland generally. Means of access to this point are numerous and easy: steamers run from Lucerne to Stanstadt in half an hour, and thence the traveller is carried on an electric tramway to Stans. The latter journey only occupies some 15 minutes. At Stans is the terminus of the funicular or cable railway, by means of which the mountain itself is ascended. Both tramway and cable line are operated by means of electric energy from the same generating station.

The difference in levels surmounted by the cable line is about 4,200ft., whilst the length of line is not more than 2½ miles. This rise would be perhaps too great for a simple funicular railway, especially as the route necessary to be followed involved a number of heavy reverse curves, besides using at certain points the bed of a mountain torrent. It was therefore decided to split up the line into three distinct sections, transferring the passengers at the two intermediate stations.

The first section—that from Stans to Koelti—ascends to a level of 800ft. or so above the terminus at the former place: the length of line is nearly a mile, and the grades vary from 12 to 27·5 per cent. The second section—from Koelti to Blumatt—has much steeper gradients, since in a length of 1,200 yards it rises over a height of 1,500ft., the grades being from 40 to 60 per cent. The third section is equally steep: the total rise is about 1,900ft. upon a length of line equal to some 1,400 yards, with similar grades to the last. On this portion also there is a tunnel 150 yards long, and a viaduct of equal length. The upper terminus is close to the Hotel Stanserhorn, from which a pathway leads to the actual summit of the mountain, 150ft. higher.

Each section of the cable line is composed of a single track, with a pass-by in the centre of its length. Two carriages are employed on each, connected to the ends of a wire rope which is wound upon a drum by means of an electric motor, fixed at the top of the section.

Electric energy for operating these cars is obtained from a water-power station situated at Buochs, 3½ miles distant, where a convenient fall is employed to drive turbines and dynamos. In case any possible accident should happen to the hydraulic machinery, and lest the water supply should fail, a steam-engine of 60 h.p. is provided at each winding station to serve as a stand-by. The cars are built with seats in tiers; they have each four compartments to hold eight persons, and, with the same number on the platform, there is a total accommodation for 40 passengers per car.

Probably the most important feature for consideration in planning a line of this kind would be the particular type of brake to employ, not only for checking the speed under ordinary circumstances, but also to hold the cars in case of a break away. With most mountain lines of any length or curvature it is found much the best and safest plan to use a rack rail, so that absolute stoppage of the car upon any grade at any point may always be ensured, if necessary, by locking the wheels. On the Stanserhorn line, however, the safety brakes come into action automatically as soon as the tension of the rope is released, just as in hydraulic lifts and elevators. The car wheels actuate another wheel, which works a screw and slide blocks in such manner as to grip the rails firmly enough to hold the car, even on a 60 per cent. grade. A special section of Vignoles rail is used for this purpose, and a pressure of 10 tons, it is claimed, can be exerted upon the rails by each of the two pairs of brake grips. A third pair is also provided for working from the platform as a hand-brake.

The terminal stations of each cable section are brought close to one another, so that passengers only require to traverse a few steps in passing from one to the other. In order to ensure the simultaneous arrival of the cars at the respective termini, the time occupied in ascending and descending each section is kept the same, irrespective of distance, and the speeds of travel are, therefore different. Thirteen minutes are found sufficient to give an average speed of 100ft. per minute—vertical lift—on each section, the entire journey on the cable line occupying 45 minutes, with an allowance for transfers at the two intermediate stations. This equals a speed of from 3½ to 4½ miles an hour—not, perhaps, very excessive—but still quite enough on such steep grades. It is, by the way, an extremely interesting fact to remember that the speed, although apparently so slow, yet consumes no more time absolutely in rising to the height mentioned than would be taken by trains running at 40 miles an hour on an ordinary railway laid out with sufficient length to reach the same altitude on maximum grades of 3 per cent.; or 20 miles an hour on 6 per cent. grades. The journey from Lucerne to the Hotel Stanserhorn is accomplished in 1½ hours, at a charge of 7s. return fare, and there is a regular service of 10 trains daily.

GAS UNDERTAKINGS IN RELATION TO THE USE OF GAS-ENGINES.*

BY H. LEES, HEXHAM.

When asked by the president to contribute a paper to the *Proceedings* of this association, I had some misgivings as to being able to deal with a subject that had not already been fully discussed by this or kindred associations. The selection ultimately made suggested itself to me on thinking over the papers and discussions at the meeting of the Incorporated Gas Institute, held at Belfast in June of last year.

It will be in the minds of many who were present at that meeting that the question of gas-engines for driving exhausters was introduced into the discussion on Mr. Bryan Donkin's paper on "Rotary Engines"; and that it was suggested by Mr. Emerson Dowson, in his paper on "Gas Power," that the managers of gas undertakings were not alive to their own interests in the attitude adopted in regard to the gas-engine. This, however, was not allowed to pass unchallenged; and enough was said to indicate that it was more than possible the opinion had been formed on insufficient evidence. To judge from isolated cases, it would be easy to get up a very strong indictment against us; while it would be quite as easy to put forth more than ample defence, by selecting a case where considerable enterprise was shown in that direction. Neither of these extremes would be a true statement of the facts; and in all probability, if we take the "happy medium," we shall be near the mark.

By the courtesy of the members of this association, I am enabled to give particulars of what is being done in the

* Paper read before the North of England Gas Managers' Association.

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use of gas-engines in the district comprised within the limits of the association. A reference to the appendix will show that out of 30 undertakings dealt with, gas-engines are used at 10. This is a proportion of 33⅓ per cent., as against 12½ per cent. stated by Mr. Dowson as the proportion for the United Kingdom. It is possible that the proportion in this district may be higher than in other parts of the kingdom; but it is difficult to give any special reason why this should be so. Where coal or coke is more expensive, the gas-engine should be in greater demand. The number of works at which gas-engines are used is not large, and it is more than probable an extension in that direction would be beneficial to some who might participate in it.

In some instances, it may be possible to show that steam is cheaper than gas even on a gasworks. But at present it is my intention to put the case for the gas-engine before you; and in doing so I have to acknowledge my indebtedness to several gentlemen who have favoured me with the benefit of their experience, which strongly confirms my own. The 2-h.p. (nominal) gas-engine in use at the Hexham Gasworks has been working constantly night and day—with short stoppages for cleaning and repairs—during the past 10 years. This is equal to a life of 30 years compared to an engine in use during the working hours of most industrial establishments. In addition to driving the exhauster, two pumps are in constant use for pumping water and ammoniacal liquor respectively. It will be understood that an engine 10 years old is not likely to be so economical as the modern gas-engine, and therefore the results in this respect are not the most favourable that could be given. The consumption of gas during the past 12 months was 366,700 cubic feet, or 42 cubic feet per hour. The cost of gas delivered into the holder may be taken at 11d. per 1,000 cubic feet. This makes a total cost of gas for the year of £16. 16s., or 0·46d. per hour. The total cost of repairs for the 10 years the engine has been in use is £25, or £2. 10s. per annum. This brings the annual cost for gas and repairs to £19. 6s., or 0·53d. per hour. The cost per 1,000 cubic feet of gas made is 0·196d. No allowance has been made for oil, etc., as in any comparison with the use of a steam-engine, this item would presumably be about the same in each case.

It would perhaps be difficult to work at a less cost than this for fuel of any other character, apart from the extra labour involved in the use of solid fuel. It may be argued that there need be no extra cost for labour on a gasworks, as the stokers could attend to the boiler. There is, however, a limit to which you can go in putting extra work on the stoker. In the case under consideration, it would not be conducive to good work to put this extra labour upon him. It may therefore be assumed that the cost of labour alone, in substituting steam for gas, would in many cases exceed the cost of gas, to say nothing of the value of fuel used.

What may be taken as a fair comparison between gas and steam is shown in the following table, based upon statistics given by Herr C. Korte in a paper read before the Association of German Engineers about two years ago. The figures contained in the table are calculated upon a working day of 10 hours; and the cost appears to include interest on capital as well as all working expenses. The price of coal taken may seem high. But it is not more than is frequently paid in this district for best steam coal; and we may reasonably assume that if an inferior quality was used, more would be required, and the cost would not be reduced.

TABLE I.—Comparative Cost of Small Gas and Steam Engines per Horse-power per Hour.

Gas per 1,000 cubic feet.	*Gas-engines.* ½ h.p.	1 h.p.	2 h.p.	3 h.p.	4 h.p.	6 h.p.
3s. 4d. ...	4·08d.	2·64d.	2·28d.	2·04d.	1·92d.	1·80d.
2 10 ...	3·72	2·40	2·03	1·80	1·68	1·56
2 6 ...	3·52	2·26	1·90	1·66	1·55	1·43
2 3 ...	3·37	2·15	1·79	1·55	1·46	1·34
2 0 ...	3·23	2·05	1·69	1·45	1·37	1·25
1 9 ...	3·08	1·94	1·58	1·34	1·27	1·15
1 6 ...	2·93	1·84	1·48	1·24	1·18	1·06
1 3 ...	2·78	1·73	1·37	1·13	1·08	0·96
1 0 ...	2·64	1·62	1·26	1·02	0·99	0·87
0 9 ...	2·49	1·52	1·16	0·92	0·89	0·77
Coal per ton.		*Steam-engines.*				
12 6 ...	—	2·88	2·04	1·68	1·44	1·32

It will be seen from these statistics that where the cost of gas does not exceed 2s. 3d. per 1,000 cubic feet, it will compete favourably with coal as regards power supplied, with engines of 4 h.p. and 6 h.p., and at higher prices in the case of smaller engines. We are, moreover, led to believe that these are not the best results that have been obtained with the gas-engine, as Mr. Dowson states in his paper previously referred to that "the makers of gas-engines are obliged to admit that, when town gas costs more than 3s. per 1,000 cubic feet, the working cost of an engine of more than 14 h.p. nominal exceeds that of a steam-engine of the same power under the same conditions of working."

The case for the gas-engine has, therefore, not been exaggerated; and when it becomes a question of getting gas at the cost delivered into the holder, the comparison is very decidedly in favour of gas. There are, however, further considerations which apply to gasworks. Coke is generally used for boilers. The value of this depends upon the local demand; and without there being any difference in the quality, it is possible a considerable difference in price may rule as between one district and another. Of recent years, by the introduction of "forced draught," the gasworks manager has been enabled to use breeze and more inferior fuel produced on his works, and which in some cases it was an expense to dispose of. It is not, however, in small works where these conditions are likely to exist to such an extent as to materially affect the cost of steam power, and it is in these that gas-engines are most useful and economical.

The use of steam appeals to us also on other grounds than that of cost, and so strong is the conviction of some that it is indispensable on a gasworks, that the question of cost would have but scant consideration. It has its uses, no doubt, and it is perhaps not too much to say that it has its "mis-uses," to which it is often applied. It is not an uncommon thing to steam out exhausters, condensers, washers, etc., and under certain circumstances this may be expedient. But is it not a practice that for many reasons should be deprecated? The knowledge that steam can be applied to these purposes often leads to the neglect of the application of means which would prevent the necessity for its use. Steam is very useful in preventing the water in the cups of gasholders from freezing; but supposing it is requisite for this and other purposes, is it wise to have a steam-boiler at work all the year round on the chance of being required two or three times during the winter, when, by the use of gas, the motive power of the works could be provided at considerably less cost? If steam is a necessity, it would be more economical in many cases to keep a small boiler in readiness for such cases.

Perhaps something should be said upon the supposed difficulties of gas-engine when applied to exhausters. It is sometimes argued that it is not possible to regulate a gas-engine to meet the fluctuations of the make of gas, so as to keep a level gauge. My experience has not been of that unfavourable character. This can be accomplished by the governor of the engine, and the usual method of by-passing; the difference between the summer and winter make being dealt with by using drums of different sizes on the exhauster shaft. It is urged that a gas-engine on a gasworks is an advertisement, and in small towns this doubtless is so. If we have faith in the use of gas-engines, we should not be afraid to show it by adopting their use where we possibly can on our own works. Having done this, we are free to recommend them to others, and this opportunity occasionally comes in our way. Mr. J. Whimster, of Armagh, who takes a great interest in the application of gas motors on small works, informs me that most of the engines introduced into his town are the result of his having called attention to the one in use at his works; and recently a 20-h.p. engine, consuming nearly one million cubic feet of gas per annum, was added to the list—directly through an investigation into the working of his own engine.

The appendix shows that the largest percentage—so far as returns are obtainable—of gas used for motive power in any town or district in the list is 4·46 of the total quantity consumed. This amount is small, and if (as we are sometimes reminded) the future of gas lies in the direction of its utility for other purposes than lighting, we may conclude

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APPENDIX TO MR. H. LEES'S PAPER ON "GAS UNDERTAKINGS IN RELATION TO THE USE OF GAS-ENGINES."

STATISTICS HAVING REFERENCE TO GAS UNDERTAKINGS WITHIN THE DISTRICT OF THE NORTH OF ENGLAND GAS MANAGERS' ASSOCIATION.

Number corresponding to name of undertaking.	Annual consumption of gas. Cubic feet.	Gas consumed per annum by gas-engines (exclusive of works use). Cubic feet.	Gas consumed by gas-engines per cent. on total consumption.	Number of gas-engines in use.	Price of gas for lighting purposes. Per 1,000 cubic feet.	Price of gas for gas-engines.	Special facilities offered for encouraging the use of gas as a motive power.	Gas-engine used on works.
1	4,000,000	nil.	nil.	nil.	3s. 5d. and 3s. 9d.	—	—	½-h.p. gas-engine for driving exhauster and pumps.
2	4,500,000	,,	,,	,,	4s. 2d. and 5s.	,,	—	No machinery.
3	10,000,000	15,000	0·15	2	3s. 3d.	Same as for lighting.	—	One gas-engine for driving exhauster and pumps.
4	12,000,000	120,000	1·00	2	3s.	,,	—	No machinery.
5	13,788,700	411,200	2·98	8	3s. 7d.	3s. 1d.	—	—
6	16,000,000	113,000	0·70	5	3s. 6d.	Same as for lighting.	—	—
7	21,000,000	100,000	0·47	6	3s. 6d.	,,	—	—
8	22,000,000	876,200	3·98	9	2s. 8d. to 3s., according to consumption.	,,	—	2-h.p. gas-engine for driving exhauster and pumps.
9	22,000,000	200,000	0·91	4	3s. 6d.	,,	—	—
10	23,005,000	1,032,000	4·46	14	3s. 3d. and 3s. 4d.	,,	—	—
11	25,000,000	495,000	1·98	8	4s. 1d.	,,	—	—
12	28,000,000	348,000	1·24	12	3s. 1d. to 3s. 5d., according to consumption.	3s., subject to 5 and 10 per cent. discount, according to consumption.	—	—
13	30,323,900	411,500	1·35	11	4s.	3s.	Meters free for gas-engines.	—
14	32,750,000	1,170,000	3·57	10	3s. 3d.	Same as for lighting.	—	—
15	34,500,000	1,373,700	3·98	14	3s.	For small engines, 2s. 6d.; 6 h.p. and upwards, 2s. 3d.	Lower rates for specially large engines. Free service pipes.	Gas-engines for driving exhauster, pumps, and oxide elevator.
16	35,000,000	nil.	nil.	nil.	2s. 6d. to 3s. 2d.	—	—	—
17	38,000,000	700,000	1·84	8	3s. 4d.	Same as for lighting.	—	—
18	43,595,000	377,000	0·87	9	3s. 4d.	,,	—	One gas-engine for duplicate exhauster.
19	80,500,000	1,847,700	2·29	13	2s. 8d. and 2s. 11d.	,,	—	—
20	120,000,000	1,000,000	0·83	25	2s. 6d.	2s. 4½d. and 2s. 3d., according to consumption.	Service pipe and meter free, and half cost of fixing.	Two 6-h.p. engines lifting coal from barges into retort-houses.
21	180,000,000	2,860,000	1·59	34	2s.	Same as for lighting.	—	—
22	200,000,000	Not recorded separately.	—	35	2s. 3d., less 5 per cent. discount.	,,	—	—
23	220,000,000	3,172,700	1·44	44	2s. 3d.	,,	Gas-engines let on hire; inspected free every three months by arrangement.	—
24	246,500,000	8,500,000	3·44	63	2s. 4½d.	,,	Easy terms of payment, fixing, etc. Undertake repairs and supervision of gas-engines.	Gas-engines used for blowing, and for driving the whole of the machinery of the fitting shops.
25	300,000,000	Not recorded separately.	—	about 30	2s.	,,	—	—
26	330,000,000	About 10,000,000	3·03	about 40	2s.	,,	—	—
27	350,000,000	Not recorded separately.	—	60 to 70	2s., 2s. 1d., and 2s. 3d., according to consumption.	,,	Sell and fix gas-engines and lay services for nominal profits, according to probable consumption.	—
28	399,258,000	,,	—	25	2s. 6d., less 7½, 10, 15, and 20 per cent., ditto.	,,	Service pipe laid free of charge.	One gas-engine for pumping water from the river.
29	646,000,000	,,	—	183	1s. 6d. to 1s. 11d., according to consumption.	,,	—	One 6-h.p. gas-engine driving 35,000 cubic feet per hour exhauster.
30	1,700,917,000	,,	—	305	1s. 10d., less 10 per cent. discount, and 5 per cent. extra discount to consumers of 400,000 cubic feet and upwards per quarter.	,,	—	Two 7 h.p., one 4 h.p., and one 1 h.p., used for driving smiths' blasts, circular saw, drilling-machines, tar and liquor pumps, &c.

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that we have a very wide field before us. Some of us, however, think we are not to be deprived of all the lighting; and so we are disposed to take a very hopeful view of future prospects. But it is no use to live in a "fool's paradise." While we believe there is a great future for gas, we also acknowledge that its attainment depends greatly upon the efforts of those who are responsible for the administration of gas undertakings, and the education of consumers. The latter is probably of greater importance than the former, and generally it falls upon the manager of a gasworks to undertake that work in addition to his already multifarious duties.

It would be difficult to lay down fixed lines upon which to work with a view to increasing the consumption of gas for motive power. Where the price of gas is as low as 2s. and 1s. 6d. per 1,000 cubic feet, one would naturally conclude that this was sufficient inducement to secure any consumption that it would be possible to get by means of concessions. Something, however, is being done to assist in various ways this branch of our business. On a further reference to the appendix, it will be seen that in one town gas-engines are let out on hire and inspected free; in another, easy terms of payment are allowed in the purchase of engine, cost of fixing, etc., and supervision is undertaken in this case also; while in a third, they sell and fix engines for nominal profits. Five undertakings make a special allowance in the price of gas used for gas-engines; and many others allow extra discounts on the basis of consumption. It has already been shown that, for small-power engines, gas is cheaper than steam when in constant work. Where the work is intermittent, the advantage is considerably increased; and instances have doubtless come within the experience of most of us where the cost of gas has not reached the amount previously paid in fireman's wages. One of the most recent developments in the use of the gas-engine is in providing power for electric lighting installations. Mr. Dowson has dealt very ably with this subject in a paper read before the Institution of Civil Engineers; and whilst his advocacy had more particular reference to the use of fuel gas, some very interesting and encouraging figures were published in regard to the use of coal gas. The case of the Morecambe electric lighting installation has done service on more than one occasion, and is still capable of being used in a most favourable light for gas as compared to steam. The statistics published in relation to it in Mr. Dowson's paper are the result of working trials made by Messrs. Andrew and Preece, electrical engineers, of Bradford. The following is one of two trials made with town gas at 3s. 3d. per 1,000 cubic feet:

Cost of gas per kilowatt	1·555d.
Cost of labour per kilowatt	0·400d.
Cost of oil and waste per kilowatt	0·013d.
Cost of water per kilowatt	0·035d.
Total cost per kilowatt	2·003d.

The following table gives a comparison of what the cost would be with gas at various prices, and under similar conditions of working in other respects; also showing the cost exclusive of labour:

TABLE II.—Cost of Generating Electricity by Gas-engines on the Basis of the Morecambe Experiment with Gas at Various Prices, Inclusive and Exclusive of Labour.

Price of gas per 1,000 C. feet.	Cost per kilowatt, inclusive of labour.	Cost per kilowatt, exclusive of labour.
s. d.	d.	d.
3 3	2·003	1·603
3 0	1·883	1·483
2 9	1·764	1·364
2 6	1·664	1·244
2 3	1·524	1·124
2 0	1·405	1·005
1 9	1·285	0·885
1 6	1·165	0·765

These figures become still more interesting when placed alongside published statistics of the working of electric lighting undertakings having statutory powers in the United Kingdom. The cost for coal, oil, waste, water, and engine-room stores (exclusive of labour) is shown in Table III. for the companies named.

These costs are exclusive of all labour, and it would only be fair to allow for the cost of firing the boilers when comparing with the gas-engine. This is not published separately, but I am able (through the courtesy of the manager of one of the companies named) to give the cost in their case. It works out to 0·25d. per kilowatt. Taking this as an average cost, and adding it to the above figures, a comparison then shows that with gas at 2s. 3d. per 1,000 cubic feet it will compete in regard to cost with the most favourable working of the companies named; and up to 3s. 3d. per 1,000 cubic feet, it is more economical than the average working of electric lighting companies' stations where steam is the motive power.

TABLE III.—Cost of Generating Electricity by Steam Power (Exclusive of Labour) at the Electric Lighting Works Named.

Name of company.	Cost per kilowatt, exclusive of labour.
Westminster	1·29d.
Birmingham	1·16d.
Liverpool	0·88d.
Chelsea	2·22d.
St. Pancras	1·91d.
Newcastle and District	1·50d.
Newcastle-on-Tyne	0·97d.
City of London	2·34d.
House-to-House	2·80d.
Eastbourne	1·93d.
Metropolitan	2·05d.
St. James's	1·06d.

I must confess that when I entered upon the work of collecting information for this paper I was not prepared for any such results, and they are not now advanced as being final. But the conclusions suggested are worthy of consideration on the part of those who may have opportunities of going further into the matter. The Morecambe results were obtained on a comparatively small scale, and in that respect they might be supposed to be at a disadvantage. The working of steam-engines in electric lighting works will doubtless be more costly than in works where a continuous run of nine or ten hours per day takes place, and the comparison with establishments of this character would be less favourable to gas where large powers were required. It is difficult to obtain the necessary information upon which to base such comparison; but from particulars I have been able to collect, though not in a form to make accurate comparison, there is no doubt the use of gas as motive power is making great strides. All who are in any way responsible for the administration of gas undertakings should aim at still further encouraging this; and I think most of us are anxious to help it on as far as we possibly can. But we have other consumers to take into consideration. There are gas-engines that do not consume more than the artisan does for lighting his cottage, and it would be unfair to make a special reduction in such cases. The same principle applies up to the point at which the gas-engine exceeds the consumption of the largest consumer for other purposes. If a concession is to be made in price, the most satisfactory method appears to be to regulate it by the quantity consumed, and in this way we shall probably secure all the consumers of this class that are to be obtained at all. Other methods may appear expedient and justifiable under certain circumstances, but speaking generally this will meet the case.

It is perhaps not too much to claim that we are continually on the look-out for any possible means of increasing the consumption of gas, and may we not now ask the more practical co-operation of gas-engine makers? That the price of the engine does more to retard an extension of its use than does the price of gas, has been borne out in the experience of many who have had the question to deal with. There have been reductions recently, and the demand has increased concurrently. Still, to outsiders it does seem possible to yet further reduce the prices. We may also reasonably expect further improvements in the construction of the gas-engine. The advances that have been made encourage this expectation; and when some of the drawbacks attributed to the use of the engine for certain purposes have been removed, and it is brought more on a parallel with the most perfect form of steam-engine, we may hope to share in some of the benefits that will accrue.

Paris.—It is proposed to light the Hospice d'Ivry electrically. Gas and oil have been used hitherto. A report has been presented on the subject by M. Davrillé des Essards.

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COMBINED DIRECT AND ALTERNATING CURRENT GENERATOR.

Two generators of a new type have recently been completed by the Westinghouse Electric and Manufacturing Company at the station of the Citizens' Light and Power Company, at Rochester, N.Y. These machines apparently mark the beginning of a new departure in station operation. These two generators, which are exact duplicates, are the first of the type built, and the success in their operation is so marked that they seem to be worthy of more than passing notice.

In the absence of a more specific trade name, the machine, according to the *Electrical World*, from which we abstract the following, may be called a combined direct-current and alternating-current generator. The peculiarity of this combination is that a direct current of 550 volts is taken from one end of the armature shaft and an alternating current of about 385 volts is taken from the opposite end of the shaft. In other words, the entire output of the generator may be utilised for direct-current work, the entire output used for alternating-current lighting and power purposes, or it may be divided between the two classes of work, in such proportions as may be desired.

The first impression produced by the new generator is its extreme simplicity of construction. The armature, which is essentially the same as the ordinary type of Westinghouse single-wound iron-clad armature for street railway generators, revolves in an eight-pole field. It revolves at a speed of only 750 revolutions per minute, giving a frequency of 6,000 alternations per minute on the alternating side. The direct-current end of the shaft is fitted with an ordinary commutator.

So far as the direct function of the generator is concerned, no explanation is necessary. The current is commutated in the usual manner, and does its work with indifference to the somewhat peculiar condition of affairs existing at the other end of the armature shaft. The alternating-current side of the generator is arranged on the two-phase system: two alternating currents are delivered on two separate circuits, with a quarter-phase difference, thus enabling alternating motors to start with good torque.

The alternating-current connection is made thus. The armature has a hollow core; the wires of the two-phase alternating circuits are given positive and negative connection to the commutator on the direct end of the shaft, the wires making suitable connections to collector rings on the alternate-current end of the shaft. Thus, while the current is commutated and sent out from what may be called the direct end of the shaft, the alternating currents are carried to the other end, and pass through the step-up transformers on to the line, with the voltage increased to 2,000. The wires passing through the hollow core of the armature are bolted in the proper position to the back of the commutator.

The fact that there is a voltage of only 385 at the alternating end and a voltage of 550 at the direct end seems to be a little perplexing. Possibly it is made a little clearer by the fact that in separate generators a direct E.M.F. is rated at its maximum, and an alternating E.M.F. is rated at the average of the curve, say, seven-tenths; and obviously, the same rating must obtain when the different currents are combined in the novel way described above. The two-phase four-wire systems are utilised in this combined generator, and it is sufficient for the present to record the fact that all difficulty of equalising the voltage on the circuit is obviated; in other words, it has been demonstrated that absolutely no balancing is necessary—a fact which will be duly appreciated.

It should be noted that while the combined generator does all kinds of work except series arc lighting the alternating feature gives all the advantage of transmission of current, besides bringing into use the important feature of self-starting alternating motors. It will be understood that, under these conditions, the generator is capable of work on the following lines: direct-current motor work; incandescent lighting by alternating current; alternating-current motor work; alternating-current arc lighting; street railway work. It is, of course, unnecessary to occupy space in pointing out the advantages to a medium-sized station, running night and day, on the various classes of work which have been enumerated, and the distribution of load from one end of the shaft to the other, at will, without shutting down. Another element must not be lost sight of, and that is the safety of operators at the station secured by the low voltage. The alternating current goes to the transformer with a voltage of only 385—a fact which tells its own story.

ELECTRICITY AS A MOTIVE POWER IN THE IRON AND STEEL INDUSTRIES.*

BY D. SELBY-BIGGE.

Electric power has been applied in this country hitherto chiefly for the purposes of traction, or for carrying out various operations in mining work, such as hauling, pumping, winding, ventilation, drilling, etc., and its chief advantages and characteristics in these branches are now very generally known. All these applications up to the present have come under the head of long-distance transmission, and there has been a general tendency on the part of engineers to consider applying electric power only in those cases where the power has had to be transmitted a considerable distance. The author is particularly anxious to draw the attention of engineers to what he may term short-distance transmission, or concentration of power. Seeing that it may be considered as coming within the scope of the iron and steel industries, ironstone mines, blast furnaces, iron and steel works, engineering shops, shipbuilding yards, the author will endeavour to point out the cases in which electric power is applicable to each of the above.

I. Long-Distance Transmission.

Ironstone Mines. — When transmitting electric power long distances it is necessary, in order to keep down the cost of the conducting cables, to employ high-tension currents—that is to say, the generating dynamos are wound to give off their power at a high voltage and small current. It has hitherto been the practice in mining work to convey the power at voltages of 300, 500, or 800 volts. Electric power in this way may be transmitted with a comparatively trifling loss to distances of several miles in length. It was not long therefore before electricity found an opening in its application to various mining operations, and especially to hauling and pumping. It was the author's privilege some two years ago to apply electricity in the Cleveland mines for drilling purposes, and since then these electric drills have proved themselves in every way a thorough success, and their use is being further extended into other mines in the district. The voltage in the case of the electric rock-drills does not exceed 300, as the power involved is comparatively small, and the distances do not exceed one to two miles in length. In the case of ironstone mines situated at any great distance from the main line, or in cases where a special line has to be built to the mines, an electric plant could be laid down, not only to operate the drilling in the mine, pumping the water, hauling out the ironstone, but could also be employed to generate current, at the same time for performing all the traction on the branch line. The whole of this work could be performed by current generated from a single engine and dynamo at the mine itself. In the case where several ironstone mines are situated in close proximity one to the other, a central power station could be laid down, by means of which there would be no separate steam plants situated at the different mines, these all being replaced by electric motors, driven off one main generating dynamo situated at the central station. There is no difficulty whatsoever in carrying out the winding, hauling, pumping, drilling, and ventilating arrangements at these mines electrically.

Blast Furnaces.—There may be some at this meeting who may think that the author now proposes to work blast furnaces by electricity. He regrets, however, it is not yet in his power to revolutionise the world by doing this. He would, however, seek the aid of blast furnaces in generating his electricity and considers that, after a waterfall, a Cleveland furnace is the next best friend to those desirous of generating electric power economically. In many cases there are large amounts of waste gases available from the furnaces. These are generally used for firing the boilers necessary for driving the blowing-engines, etc., but there is frequently a considerable amount of waste gas left over. It is with this waste gas he would propose firing the boilers in connection with the electric generating plant. The power thus generated could be transmitted at a high tension to engineering works situated at a considerable distance, and, if necessary, transformed again to a lower tension for use in the works. At blast furnaces themselves there are not a great number of applications to which electricity could be adapted for driving purposes, excepting, perhaps, in pumping water from a neighbouring river for condensing. The mineral hoists could be worked electrically.

II. Short-Distance Transmission and Concentration of Power.

Iron and Steel Works.—By short-distance transmission the author means the distribution of electrical energy for the purposes of driving engineering works. First of all, let the case of iron and steel works be taken, and the classes of machines most frequently employed in these works be considered. These will be found in a great measure to consist of the following: punching and shearing machines, straightening machines, cold and hot saws, drilling machines, planing machines, blowers, overhead travellers,

* Abstract of paper presented to the Iron and Steel Institute.

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TABLE A.—Electric Motor Tests taken at the Works of Messrs. Dorman, Long, and Co., Middlesbrough.

Description of machine.	Driven by engine capable of indicating	Replaced by motor capable of indicating	Voltage at generator.	Voltage at motor.	Current taken by motor.	E.H.P. absorbed in doing work.
Group of machines as under—	H.P.	H.P.			Amperes.	Per cent.
Three cold saws Two ending machines One saw-sharpening machine	27	10½	120	115	70	10·7
Troughing straightening machine	14	3½	120	118	12	1·9
Double-ended punch, punching four holes one side and one other	14	5	120	115	25	3·7
Straightening machine, all sections	14	3½	120	115	15	2·3
Straightening machine, biggest sections	16	3½	120	115	35	5·4
Cold saw, 26in. diameter	9	3½	120	110	15-27	2·2 and 3·9

The saving in coal effected on above machine tools amounted to 30 tons per week, after the adoption of the electric system.

locomotive cranes, rolls, winches, scrap breakers, etc. In connection with iron and steel works there are frequently found girder shops, fitting shops, etc., in which the machinery is driven through shafting and belting off one or more engines situated in the shop. In laying down machinery of the above class it has almost invariably been the practice, not only when the machine tools are driven by separate engines, but also when they are driven by belting and shafting, to make allowances in these engines for very large losses, due to condensation or leakage in steam-pipes, or to friction caused in the belting and shafting. It is a well-known fact that the power actually expended in performing the work on these various machines is a mere fractional part of that transmitted from the generating source. Although attention has been paid to the economy of the main engines, the question of that in the small engines driving these machine tools, and the conveyance of steam, has often been entirely overlooked, and an enormous waste has been going on in this manner for years past. With the advent of the electric motor this condition of things was at once changed.

Table A gives results of experiments that have been recently carried out by the author, in conjunction with Mr. H. Panton, on the actual power absorbed by various machine tools in doing their work. The figures are extremely interesting, as showing the very small amount of power absorbed by the different tools when doing their work.

The author now wishes particularly to draw the attention of engineers to the concentration and distribution of power in works by means of electricity, and in order to fully demonstrate his ideas on this subject he has had two diagrams prepared, one showing the various cases of power transmission one meets with at an old works, and the other showing the way in which these works could be remodelled, and what savings could be effected by a judicious application of electric power. Of course the works represented above are purely imaginary, but it will be found that almost any other works will contain some or other of the examples of power transmission depicted on this plan. The plan contains examples of power transmission met with in iron and steel works, engineering shops, shipbuilding yards, etc. In the case of the old works there are examples: (1) of a large number of scattered steam-engines; (2) long lines of shafting and belting in the various shops; (3) considerable lengths of steam-pipes; (4) separate and scattered groups of boilers; (5) low-pressure steam; (6) old or uneconomical engines, especially in the smaller sizes; (7) intermittent character of the work. Turning back to these cases, it is very evident to all engineers the great economy which would be realised if all these scattered engines could be concentrated in one large and highly efficient engine. The amount of coal taken per unit of work done would necessarily be very much less, and in replacing these engines by electric motors the services of a large number of men could be dispensed with. Taking the second case of shafting and belting, the author thinks that few engineers really realise what is actually lost in the transmission of power through long lines of main shafting, countershafting, pulleys, belts, etc. The power lost has often been ascertained to vary between 30 and 69 per cent. of the total power transmitted.

The author will now proceed to demonstrate a manner in which these old works could be entirely remodelled so as to effect an enormous saving both in coal consumption, wages, and upkeep. The first thing to be done is to make a general survey of the whole works, and to have as many engines indicated as possible. Where this cannot be done, it would be advisable to lay down a small temporary installation of an engine and dynamo, with a motor which could be transferred from one machine to the other, in order to ascertain accurately the exact power absorbed by the machine in question. In this way an accurate opinion could be formed of the amount of power actually required for operating the different machines throughout the works. Having arrived at the total horse-power absorbed by all the scattered and outlying machinery, it is advisable to divide this into, say, two units of power. If the total power involved is 1,000 h.p., this would mean that it would be advisable to have two units of 500 h.p. each. The reason why so large a power is selected as unit is that in electric power installations the load diagram will be found to be of quite a different nature to that of an electric lighting station, which exhibits a more or less constant rise and fall according to the time of day, whilst the load-line in an electric power station is of a very different and fluctuating nature, varying at times between a quarter and full load, half load and full load, and so on. It is necessary, therefore, both for simplicity in working and for economical reasons, to have a steam dynamo capable of giving out current for at least half the installation. It would be necessary in the case of the five small machines to keep them all running, even if the load was only 25 per cent. of the total, in case at any moment the load should suddenly rise. This practice has been adopted in nearly all large power installations on the Continent, and the author cannot help feeling that it is the right one. In the case of works where waste furnace gases are available, the evident site for the generating plant would be in close proximity to these furnaces, in order that the boilers of the generating plant might be fired by the waste gases, the cost of the production of the electric current being thereby reduced to a minimum. Should there be no waste furnace gas available, the generating plant should then be placed close to the main battery of boilers in the works, and if these boilers are of a pressure below 80lb., it will be found economical to lay down entirely new boilers of, say, 150lb. to 180lb. pressure. Having settled on our site, the next question to be decided is the form which the generating plant should take. In the case of a unit as large as 500 h.p., one out of three alternatives may be resorted to; a compound condensing Corliss engine running at 80 revolutions per minute, with a multipolar dynamo, built up after the continental fashion with the armature forming the flywheel of the engine, may be employed. Great confidence may be placed in a plant of this description, but the initial cost is comparatively a large one, owing to the large dimensions of the dynamo and the slow speed at which it runs. If this speed were doubled, and an engine running at, say, 160 revolutions a minute taken, it would be possible to employ a triple expansion marine engine provided with condensing arrangements. A great reduction will be effected in the cost of the dynamo, and an engine of this type should work with great economy. It will be found necessary, however, to provide this marine engine with proper automatic expansion and regulating gear, owing to the variations in load and the necessity of absolute steadiness in running. The third alternative is still further to increase the speed of the dynamo, and to employ an engine of the high-speed type, similar to those adopted in our electric lighting stations. These engines would run at about 300 revolutions per minute, thereby doubling the previous speed of the dynamo, and again reducing its cost. These high-speed engines would be of the triple-expansion type, and provided with condensing arrangements. Their consumption should not exceed 15lb. of steam per indicated horse-power per hour. In any case, the plant to be laid down should be of the steam dynamo type—that is to say, steam-engine and dynamo combined on one and the same bedplate, and direct coupled.

Having taken a decision as regards the generating plant, it is necessary next to consider the actual application of the electric motors themselves to the various machines, and the distribution of the power generally. As works which have not a greater extension than 300 or 400 yards in length are now under consideration, the voltage which will be employed will be of a low tension. In this manner can not only the whole of the power be run off the one single generating plant, but the entire lighting, both arc and incandescent, of the works themselves. The author considers that the voltage in such a case should be 120 volts. If the distances are too great to allow of this, owing to the expenditure in copper, the voltage could be increased to 500 volts. In iron and steel works, however, the low voltage is for many reasons preferable, as it is far easier to maintain a high insulation on a low voltage system than it is when a high voltage is employed. In all cases where new machinery is ordered for extensions or otherwise in the works, it would be preferable to embody the electric motor in the actual construction of the machine tool itself. In the case of old works this is hardly feasible, and the next best thing to do is to drive direct by belt on to the flywheel of the machine in question.

Supposing that the whole of the outlying machinery is actuated by electric motors, and that motors have been substituted for the engines and boilers on the overhead and locomotive cranes, that the driving power in the fitting shops and other places where shafting is employed has been split up, and that separate motors have been applied to the various countershafts, the following are the practical results which will have been obtained by remodelling the old works on the lines described.

Coal Consumption.—The total efficiency of the new installation, provided that the distances involved do not exceed 500 yards,

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should attain 75 per cent. The loss of 25 per cent. would be made up as follows;

	Per cent.
Loss in main generating dynamo	7
Loss in the mains	3
Loss in the motors	15

In many works where the engines are very much scattered, it will be found that the coal consumption per horse-power of work turned out will amount from 8lb. to 15lb. of coal and even more. Although a great reduction in the coal consumption will be effected through the use of the improved class of machinery employed and means for transmitting the power generated, there is another way in which the coal consumption can be further decreased, and that is by the instantaneous switching off of the motors when not in use. It is advisable that in every case the electric lighting of the works should be combined with the power, current for the lighting being obtained from the same generating dynamo.

Wages.—The next point to be considered is that of wages. It is evident that by the entire suppression of the scattered boilers, the services of a considerable number of stokers can be entirely dispensed with. This is also the case with those steam-engines which require an engineer to run them.

Upkeep.—We have now a further point to consider, and that is the question of upkeep of such an electrical installation. The upkeep on electric power installations which have already been running over three years, involving the use of a large number of motors, arc lamps, etc., has proved that this can be safely estimated at something under 5 per cent. on the total capital expenditure of the electric installation. No hard and fast rule, however, can be laid down for the exact cost of upkeep, as this must necessarily vary with the different classes of works to which electricity is applied.

Control.—The author thinks that one of the most important features in connection with electric power installations is the absolute check or control one has over the coal consumption and running expenses at the works. By means of an automatic registering ammeter placed in the main dynamo circuit, the total amount of power going off into the works will be recorded on a card, and the coal consumption for the day having been kept, the cost of production per unit of electrical energy can be ascertained. Owing to the self-indicating nature of electric motors, in this and other ways can a most perfect check be kept on the running expenses of the electric power plant, and the slightest loss due to leakage or undue resistance in any part of the electrical apparatus can be at once detected and remedied.

Rolling Mills.—It is quite within the bounds of possibility that electricity may find a new opening in its application to driving the lighter class of rolling mills. The result, as far as economy in steam consumption is concerned, would show a great saving on methods formerly employed. The saving would be arrived at in the following manner: Instead of the present form of engine used for actuating the rollers, which is necessarily of a somewhat uneconomical nature owing to the work it has to perform, and in which the cut-off is of a very imperfect character, an engine could be laid down on the most highly economical principles, working at a high pressure, with three expansions of steam, and taking not more than 1½lb. of coal per 1 h.p. per hour. This engine would be coupled direct to a dynamo of suitable power, and the steam dynamo generator would be kept running continuously. On each set of rollers would be directly coupled an electric motor. The switching apparatus would be worked by means of hand and foot levers, almost in identically the same manner in which the steam is shut on and off existing rolling-mill engines.

The main advantages, however, to be derived from the electric system would be the following: (1) The question of dead centres would be practically eliminated—an electric motor in itself, unlike a steam-engine, having no dead centre. The main engine driving the generating dynamo being kept continuously running, the difficulty of dead centres would be overcome there also, the result being that the total size of the engines employed would be considerably reduced, as in the present case it is necessary that either cylinder of a rolling-mill engine should be capable of starting the rolls from nothing to full load, in case one of the engines should be on its centre. (2) Owing to this new arrangement of driving, a totally different class of engine could be employed to what is now used, and instead of using 7lb. to 8lb. of coal per indicated horse-power owing to its imperfect cut off, the coal consumption should be reduced to 1½lb. per indicated horse-power. (3) A considerable number of small mills could be actuated in totally different parts of the works by means of one generating engine and dynamo, and would thus save wages and upkeep over several smaller engines scattered about. (4) The whole of the auxiliary engines required for working the live rollers, elevating, or transverse gear, overhead cranes, etc., could be replaced by electric motors all worked off the one generator. (5) Great economy in steam consumption owing to concentrating the production of the power in one spot, under highly efficient conditions.

Engineering Works and Shipbuilding Yards.—The same arguments apply to the application of electricity to engineering shops and shipbuilding yards as have already been cited. The following table, calculated by Mr. Félix Mélotte, shows a very interesting comparison between the efficiencies, obtained on a varying load, of electrical and mechanical transmission of power.

From this table it will be seen that the two systems of transmission, which at first appear to be equivalent, become very different as the load diminishes. Thus, when only one-fifth of the power is developed, electrical transmission still yields 47·2 per cent., whilst mechanical transmission has had all its power absorbed in the constant frictional loss of 206 h.p.

Electrical Transmission:						
Load on the engine	1,000	750	500	333	250	200
Constant frictional loss	50	50	50	50	50	50
Variable electrical loss...	50	27	11	4·5	2·2	1·2
Total loss in dynamo ...	100	77	61	54·5	52·2	51·2
Available power of dynamo	900	673	439	278·5	197·8	148 8
Efficiency, per cent.....	90	89·7	87·8	83·5	79·1	74·4
Loss in conductors	18	10	4	1·7	0·8	0·5
Energy available at motor terminals	882	663	435	276·8	197	148·3
Of which, 6 per cent. frictional loss..... ..	53	53	53	53	53	53
4 per cent. variable loss	35	20	8·5	3·4	1·7	1
Total loss in motor	88	73	61·5	56·4	54·7	54
Power available	794	590	373·5	220·4	142·3	94·5
Final efficiency, per cent.	79·4	78·7	74·7	66·2	57	47·2
Mechanical Transmission:						
Load on engine.....	1,000	750	500	333	250	200
Loss in shafting, etc. ...	206	206	206	206	206	206
Useful effect	794	544	294	127	44	0
Final efficiency, per cent.	79·4	72·5	58·8	38·1	17·6	0

Results Obtained.—There are few works in this country, if any, that are solely actuated by electricity. The principal applications of electric power for driving works, up to the present, may be found in the workshops of electric manufacturers themselves, who have naturally had more opportunities for investigating the advantages to be derived from electric driving. In order to give some idea of results actually obtained in the running of works for a considerable period, the author will take some figures from electric power installations carried out in Belgium, which have now been running some three years, cases in which the entire works have been actuated solely by electric power. One of the first, and perhaps most important, electric power installations that has been laid down in that country is that of the National Arm Factory, at Herstal, near Liège.

Following the example of the National Arm Factory, the Belgian Government decided to remove all the steam-engines and boilers from the Royal Arm Factory at Liège, and to replace them by electric distribution. It was ascertained that for a certain portion of the work which, previous to the introduction of electric driving, had taken three tons of coal per day, this was found to have immediately come down to 900 kilogrammes, or less than one ton, for the same amount of work done.

About a year and a half ago a 100-h.p. dynamo and six or seven motors were laid down at the glassworks of the Val St. Lambert, Belgium, the total efficiency attained coming out to 75·5 per cent. At the zincworks of the Vieille Montagne Company a large electric power installation has lately been laid down, by means of which these old works will be entirely remodelled, every engine and boiler on the place being done away with. The efficiency of the engine is 90 per cent., that of the main generating dynamo 90 per cent. at full load, and the efficiency of the distributing cables, also at full load, is 98 per cent.; the average efficiency of the motors is 86 per cent., and the commercial efficiency of the whole installation is therefore 68·5 per cent.—that is to say, the proportion of the work done to the indicated horse-power of the steam-engine. A continuous-current transformer is used to reduce the voltage from 500 to 100 volts for lighting purposes. Several works in Germany and Switzerland are also operated solely and entirely by the electric system.

Conclusion.

Taking into consideration all that has been stated in the preceding, it will be seen that electric power is destined in the near future to become an important factor in the iron, steel, and engineering trades. Whether applied for the purpose of long-distance transmission at the mines, or for short-distance transmission and concentration of power at works, great economy will be realised in wages, fuel, and upkeep over methods hitherto employed. Old works can be remodelled with advantage, as shown in the cases of the Royal Arm Factory and the Vieille Montagne Zincworks in Belgium, and the case of Messrs. Dorman, Long, and Co.'s steelworks at Middlesbrough, and what possibilities lie open to those contemplating laying down entirely new works! The Bedson Wire Company finally decided on adopting electricity as their sole power for manufacturing purposes. These works in may respects are so entirely novel, the question o economy has been so minutely gone into, that the author believes that Mr. Bedson, in the course of a few months, will be able to publish a record in working efficiency and steam consumption which has seldom, if ever, been equalled. Messrs. Bell Bros., of Middlesbrough, who have also been taking great interest in the electric power question for some time past, are installing electric power at their Clarence Works.

INSTITUTION OF ELECTRICAL ENGINEERS, May 10.

Sir David Salomons in the chair.

At last night's meeting of the Institution the following candidates were balloted for:

Associates.—Frederick Herbert Berry, 14A, Clerkenwell-green, E.C.; Arthur Carpenter, 15, Clonlee, Larne, co. Antrim; Harold William Couzens, Corporation Electricity Works, Taunton; Svend Aage Faber, 1, Fern Villas, Albert-road, Teddington; A. G. Jeffreys, Woodridings, Pinner, Middlesex; Chas. Wm. Godson Little, 38, Parliament-street, Westminster; Thomas Blackwood

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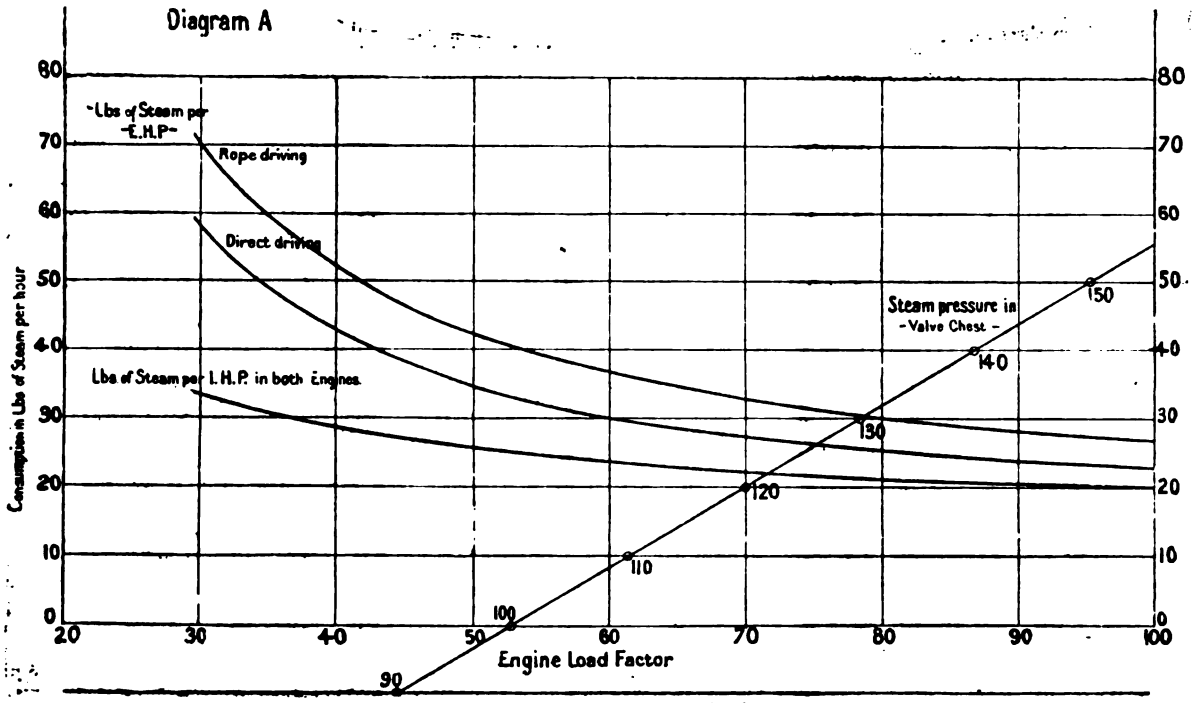
Murray, B.Sc., Heavyside, Biggar, N.B.; Richard Wesley Olver, care of Rev. G. W. Olver, B.A., 10, Clifton-road, Brockley, S.E; William Turvey, 4, Aubrey-walk, Campden-hill, W.

Students.—Ernest Cardin, North Hills, Thurlow Park-road, West Dulwich; Reginald Charles Carty, 40, Woburn-place, Russell-square, London, W.C.; Walter Harding De Winton, Gerald Graham, and Arthur Patrick O'Brien, Faraday House, Charing Cross-road, W.C.; Robert John Strike, 116, Flinders-street, Moore Park, Sydney, N.S.W.

THE COST OF ELECTRICAL ENERGY.

The accompanying diagrams are three of those referred to in the paper read before the Institution of Electrical Engineers by Mr. R. E. B. Crompton on "The Cost of Electrical Energy," and which was published in our issue of the 27th April.



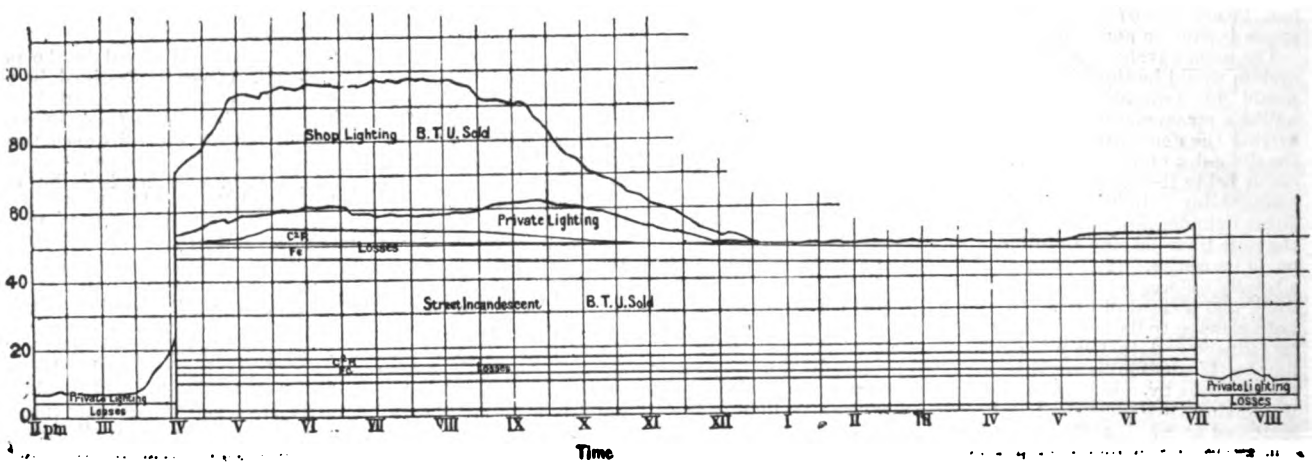
Calculating the Load Factor at Stations.

Discussion.

Mr. Raworth, who opened the discussion at the previous meeting, said that the paper was most comprehensive, and that it seemed to include nearly the whole education of the electrical engineer. The author had thrown up Lancashire boilers and pinned his faith to those of the Babcock type. It was a good effort to endeavour to reduce the cost to 3d. per unit to consumers. At Bradford and Newcastle they already delivered eight units per £1 of capital expenditure, the St. James's Company five units, the Westminster four, the Liverpool four, and Oxford two units. The system at Oxford, although perfect, appeared to cost too much to pay a dividend to the shareholders. With regard to the power question, it was only of late years that they had had the advantage of accurate tests carried out by Prof. Kennedy and others. The speaker had never bought any boiler other than the Babcock, except under compulsion, and he had put down more than half of the Babcock boilers sold in this country. They had given him perfect satisfaction, and he agreed with the author that they did not give wet steam. He was also in accord with the author that the increased efficiency of the engine should come out in units. Concerning the question of alternators, they had found out that if they could get rid of the ropes they would do better, 6 per cent. being lost by the use of ropes. As soon as they were able, they abandoned the rope driving and adopted direct operation. He hoped next time the author would give them better figures for the alternating plants than he had now done. With regard to engine losses, the Willans engine was particularly efficient from the point of view of the makers; an efficiency of 89½ to 90 per cent. was good. But it was owing to the fact that the makers of ordinary double-acting engines had never been in the habit of testing these engines that the efficiency was not a top efficiency. He could get, and anyone could get, ordinary vertical double-acting engines giving 92 per cent. There was no difficulty about it. Double-acting engines could be made to go up to 95 per cent. The author had, he thought, fallen into a serious error in regard to the efficiency of distribution in alternating-current systems, but he would leave that matter to experts.

Mr. Crompton made some additional remarks before the resumption of the discussion. With regard to the boiler-test diagram, it was interesting from many points of view. It showed that the evaporation of pounds of water per pound of coal had risen to 9 from 5·2. This class of test was one which should be made frequently at central electricity stations as leading to economies.

Major-General Webber stated that, having read the paper carefully, he found that it was open to a good deal of criticism. Why was 5,000,000 units selected by Mr. Crompton as his ideal? Mr. Crompton must have been dealing with a load for lighting purposes. In Kensington, which Mr. Crompton knew best, most of the demand was for incandescent lamps. He wanted to know on which system the author had based his possible estimate. Of three London companies respecting which figures were available, the capital expenditure per lamp was £3. Did Mr. Crompton expect to bring it down to £1 6s? Only 40 miles in London of the districts lighted were laid with mains on each side of the street. Was the author's ideal based on the future of a district like Kensington. Coming to the question of Mr. Crompton's method of collecting his information, in the letters which had been sent out by Mr. Crompton to the engineers of stations, the questions had been put in such a way as to lead to



Analysis of Load Curve at Chelmsford Station for December 9, 1893.

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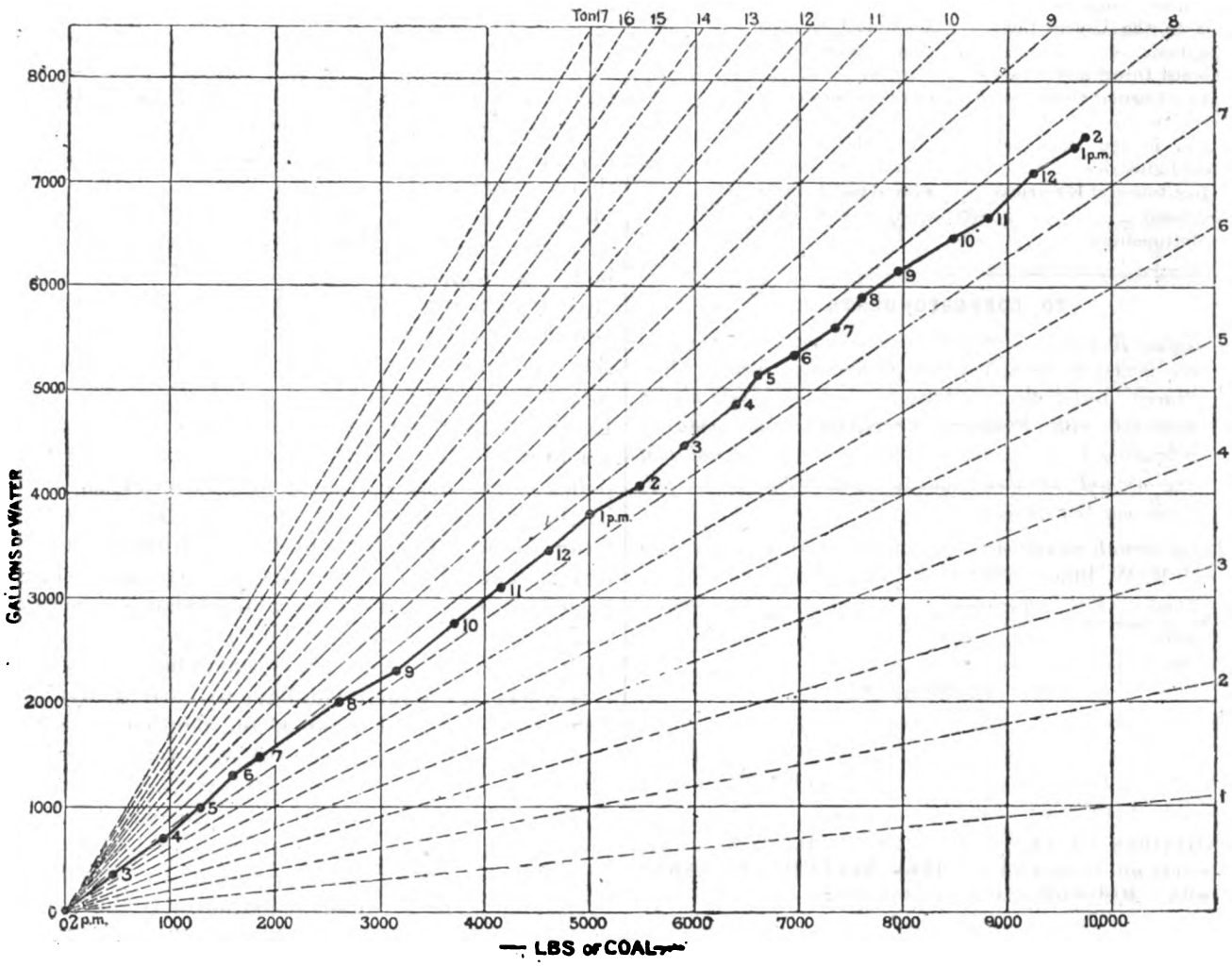
certain results being obtained. He had also stated that if the full information was not given he was prepared to fill up any information omitted, from data in his possession. In one case the speaker knew the engineer had declined to give information at all. The engineers would have been glad to do so had they been allowed to compile the tables. Chelsea was a mixed station, with accumulators, transformer-motors, etc., but had been omitted from the mixed system in Mr. Crompton's table. If Mr. Crompton, in drawing up his figures, had confined himself to those companies with which he was connected, the results would have been far more reliable than the tables which had been compiled, No. 6 being the crux of the whole matter. When Mr. Crompton gave 3d. as the price, with 1·68d. as profit, it left doubts as to whether Mr. Crompton was convinced of the soundness of his results.

Mr. Mark Robinson said that if Mr. Crompton was ahead, yet some of his prophecies had come true, and the speaker hoped that that would be the case with respect to the theory of a consumption of 2·5lb. of coal per unit. It rested on the evaporation of the boilers, the consumption of the engine, and small friction. In reference to the dryness of steam from water-tube boilers, he had at Thames Ditton found wonderful results from a Nicholas boiler—a French water-tube boiler. There was only ¼ per cent. of moisture in the steam. The boiler had also been worked at double its rated capacity, and then the moisture was 1 per cent. Much the same results had been obtained from a Babcock boiler. As other views had been held at Thames Ditton, he considered it but fair to mention this. As regarded the consumption of only 12lb. of steam by the engine, this had been done by the Sulzer engine. A large mill engine had taken 13½lb. A large high-speed engine could work on 13. By jacketting, etc., a high-speed engine could be brought down to the consumption of the Sulzer, but there would be disadvantages in connection therewith, as the lowest steam consumption could not be obtained in the same engine as the lowest friction. Mr. Raworth had gone a little for the Willans engine by saying that it had a good brake efficiency, but so had all vertical engines. Now, large compound or triple-expansion engines were not readily handled on brake trials, and it did not seem safe to judge of the efficiency running loaded by what the efficiency might be running light. With single-acting engines the losses due to friction were almost constant. Messrs. Mather and Platt were making for the speaker a brake for 1,200 h.p., and they hoped to run a large engine on it which would settle various points. The result of a number of tests made at Thames Ditton showed an average of 90·6 brake efficiency with new and stiff engines. The speaker considered that Mr. Crompton had made an excellent suggestion when he advised the use of a pressure gauge on the steam chest. It was of much value, though not with automatic expansion gear.

Mr. Geipel said it was encouraging to find that 3d. was the price within measurable distance, but Mr. Crompton had been too modest. He did not see why Mr. Crompton had reduced the prices for wages, maintenance, etc., and not the first cost of the installation. He thought that engineers could do something in the latter direction. Often unnecessarily expensive chimneys were built and condensers were erected for a full load, and were only in full use at distant intervals. He considered that the first cost might often be reduced to half that of Mr. Crompton's estimate if high-tension generators and low-tension distribution were employed. Coal would be far dearer, stores would be double, and wages and maintenance also double Mr. Crompton's. Economy could be effected by setting boilers so as to minimise loss by radiation, and the speaker described how he had set a Babcock and a Lancashire boiler with that object.

Mr. Schonheyder said that in making the boiler experiments the pounds of water evaporated per square foot of heating surface should have been stated. The author had referred to his (the speaker's) meter, which had generally worked satisfactorily. That meter had lately been improved, and now, as far as his experience went, it would get over the difficulties incurred in measuring hot water.



Clinometric Chart of Boiler Trial.

Mr. Hammond, in the course of a rambling speech, said he would have liked half an hour to discuss the matter. He stated that the paper was a very valuable one The figure of 3d. per unit, with an output of 5,000,000 units meant £62,500 per annum. Perhaps Mr. Crompton would inform them how many towns in England had gas companies with such an income, at, say, 1s. 6d. or 1s. 9d. per thousand, corresponding to 3d. per unit. The author had omitted the question of depreciation, and that was an important matter, notwithstanding the keeping of plant in a good condition.

Mr. McLaren contended that in the published tests of engines the information was often incomplete and misleading. If an engineer was laying down an installation and accepted the figures of tests put before him he might be very far astray. The true secret was to test the engines in connection with the boilers they had to work with, and, having carefully noted the data, to see what the actual consumption was. The evaporation of a locomotive type of boiler was very much nearer 10lb. than 7lb. as stated by the author. The great economy at Oxford was due to the triple-expansion slow running engines.

Mr. McLane made several corrections concerning the author's statements in regard to the Oxford station.

Mr. Burnett having made a few remarks on the boiler question, the discussion was adjourned until the 24th inst.

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THE
ELECTRICAL ENGINEER.

Published every Friday.
rice Threepence; Post Free, Threepence Halfpenny.
Editorial and Publishing Offices:
139-140, SALISBURY COURT, FLEET STREET,
LONDON, E.C.

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TO CORRESPONDENTS.

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All communications intended for the Editor should be addressed C. H. W. BIGGS, *139-140, Salisbury Court, Fleet Street, London, E.C. Anonymous communications will not be noticed.*

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THE METROPOLITAN.

It is not often we have any sympathy with the contents of the *Journal of Gas Lighting*, etc., or its electric lighting memoranda, but with its last issue we have something in common. We must give our contemporary credit for ability to find out and state plainly everything that is said or can be said against electricity. A red rag to a bull is a mild irritant compared with the word "electricity" to this gas journal. Its cursing, however, has had little or no appreciable effect upon the progress of the industry, and, with commendable consistency, it has never tried blessing. This week it devotes a considerable space to the consideration of what Sir John Pender said to the Metropolitan shareholders at their meeting. Now, if there is one man living whose speeches are not worth listening to, or who can in speaking cram more platitudes into a given space of time, that man is Sir John Pender. Of all the companies he is connected with—and their name is legion—we doubt if there is one that shows a worse history than the Metropolitan. Its conception was unsatisfactory, inasmuch as very large sums went to somebody or somebodies as promoters. Then we always look upon founders' shares with suspicion, and that distrust we find is general among the real investors, many of whom refuse to invest in a company where founders' shares exist. Further, as we said when giving the balance-sheet, we do not believe in it. We do not believe in that policy of charging certain items to capital, as shown by this balance-sheet. It allows of too easy manipulation in order to show a profit and distribute a dividend. The misfortune is that the shareholders at their meetings sanction the whole balance-sheet and whitewash the directors. The men we sympathise with in such companies are not shareholders, but the real workers, the men who have to earn a dividend upon a large capital when a considerable portion of that capital has not been spent productively. A steam-engine of so many horse-power can under ordinary circumstances only earn—when used for electric light purposes—a certain amount in the year, and this is the one point to which we should like again and again to direct attention. If the capital is spent in some other direction than plant, the return for it is limited to the amount capable of being earned by the plant. It is not very difficult to obtain a fairly accurate forecast of return. Taking the Metropolitan still as an example, we are told that the average price per lamp is 8s. 9d., and that the number of lamps connected is one hundred and seventy-five thousand. The gross return upon that average number of lamps for the year could only be £76,562. The net return according to this year's balance-sheet is as sixteen to sixty-nine; so with a revenue income of £76,562 the net return would be under £18,000. From these considerations it is seen that unless considerable economies can be effected in the management and generation costs, it will require at least another one hundred thousand lamps to be supplied without further increase of capital in order to get a 5 per cent. dividend. But Sir J. Pender says that more capital is wanted. Is it

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not almost time that shareholders began to ask Sir J. Pender what he knows about the whole matter, and to get an independent examination as to the exact capabilities of the company's work? We have merely taken the balance-sheet and the chairman's speech as our guide, and they show us how utterly mismanaged the whole concern is. Our contention is—and we think we can prove it up to the hilt—that when the supply of electrical energy has failed it has been owing to gross mismanagement, and not to any other cause. Hence we are doubly anxious that these selected points of attack by the gas journals should not be generally accepted as points which those interested in the electrical industry would support.

THE LONDON ELECTRIC.

It is more convenient to keep our remarks concerning the London Electric Company distinct from those on the Metropolitan. The company that hath no history is in a happy position, but that is not the case with either the London or the Metropolitan. According to the reasoning pursued with the Metropolitan, the London, with only sixty thousand lamps, and a capital of close on a million pounds, is, so far as its shareholders are concerned, in a perilous state. But long ago the shareholders of the London gave up hopes of getting a good return for their money. Up to the present balance-sheet the figures have been adverse. Now they about balance. We had hoped to have seen a little further progress. It is long since we pointed out that according to the then price of the shares, if the company ever paid a very moderate dividend the investment of those who came in at the low prices would be good. The quotation has now hardened up to one for the five pound share, so that 1 per cent. on the nominal capital requiring a distribution of ten thousand pounds for dividends would give 5 per cent. on the purchase. Supposing the rate of increase to be during the current year the same as it has been during the past and no increase of capital, the amount available for dividend would be about four thousand pounds. But, unfortunately, it seems that there must be a further increase of capital, so that the future prospect of dividend depends somewhat upon that increase. A comparison of the last two balance-sheets will show that with a decreased charge per unit the total amount received has increased, while considerable saving has been made in various directions. Perhaps, however, the most important paragraph in the whole report is that of the engineer when speaking of the new transformers. We are, fortunately, able to extend that paragraph. The total horse-power of transformers used is 3,487, of which, as will be seen in the report, 1,477 is new since the last month of the year. The insertion of these new transformers raised the efficiency of distribution no less than 18 per cent., and it is estimated that when all the old transformers are replaced by the new type, the efficiency of distribution, which at the end of the December quarter was only 45·43 per cent., will be raised to about 70 per cent. Electrical engineers will, we feel assured, be glad to have these figures, and we must congratulate the engineer, directors, and management of this company for having stuck to their work and brought matters to such a point that an income may confidently be expected.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

WRIGHT'S DEMAND METER.

SIR,—I notice some remarks were made at the meeting of the Northern Institute of Electrical Engineers raising the question of the drop in Mr. Wright's demand meter in use at Brighton. It will probably interest your readers to know that the total energy absorbed in the small instruments at their fullest possible load is only three watts, and in the large ones only seven watts. It is obvious that as the maximum drop is, of course, equal to these figures divided by the maximum current, it is so small as to be negligible in ordinary installations.

Thus, in practical working, the drop in a 25-ampere instrument when carrying its average load of two-thirds of its possible capacity will be ·28 of a volt, which I think warrants my saying it may be disregarded.—Yours, etc.,

(For the Reason Manufacturing Company, Limited)
HERBERT C. HUGHES, Secretary.

Brighton, May 8, 1894.

THE PRELIMINARY EXAMINATION IN "ELECTRIC LIGHTING AND POWER DISTRIBUTION."

SIR,—Following is a copy of a letter addressed by me to Sir Philip Magnus, relating to the way in which candidates in the above examination are to have the results made known to them. This and the reply thereto will, I venture to think, be of interest to both teachers and students.

There is little doubt that the number of candidates will rapidly increase year by year, and it is to be hoped that at some future time the institute authorities may see fit to modify their decision.—Yours, etc.,

W. PERREN MAYCOCK, M.I.E.E.

Croydon, May 9, 1894.

[COPY.]

"26, Stafford-road, Croydon,
"May 5, 1894.

"Sir Philip Magnus, Secretary, Examinations Committee,
"City and Guilds of London Institute, Exhibition-road,
"South Kensington, S.W.

"Dear Sir,—With reference to the newly-instituted preliminary examination on 'electric lighting and power distribution,' may I ask in what manner the results will be made known to the students?

"It has been a matter for surprise to others besides myself that your committee should have decided not to give certificates for this examination, but if each successful candidate is to receive a note from the institute recording his success, that would in a measure make up for the absence of a formal certificate. From several years' workshop experience I know there are very few electrical artisans proper who can hope to pass beyond the preliminary grade of this subject: to this numerous class of workers, some duly authenticated acknowledgment of their having passed the examination in question would often prove of considerable value. If you will clear up this point, you will confer a great obligation on other teachers than myself and on the students, to whom they have to make known this correspondence through the medium of the electrical Press.—I am, Sir, your obedient servant,

(Signed) "W. PERREN MAYCOCK."

[COPY.]

"City and Guilds of London Institute, Examinations
"Department, Exhibition-road, S.W., May 7, 1894.

"Dear Sir,—I need scarcely point out that the question

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of granting certificates on the result of the preliminary examination in electric lighting has been carefully considered by the several committees of this institute, and that the rule in the programme is the result of much deliberation. A list of candidates who may have passed that examination will be forwarded, as stated, to each centre at which they were examined, and it will be left to the local secretary to inform each separate candidate of his success or failure.—I am, dear Sir, yours very truly,

(Signed) "PHILIP MAGNUS.

"W. P. Maycock, Esq.,
" 26, Stafford-road, Croydon."

STORAGE BATTERY TRACTION IN PARIS.

An interesting feature of the French Physical Society is the fact that on the occasion of its annual exhibition a visit is paid to some works in the neighbourhood of Paris. The annual exhibition for 1894 took place two or three weeks ago, and an opportunity was afforded the members of inspecting the accumulator station at Saint-Denis, where the batteries used for traction purposes on the two lines—Paris-Saint-Denis—by the Compagnie des Tramways Nord are charged. M. Dieudonné, who describes in *L'Electricien* of May 5 the plant at the charging station, remarks that the installation is on a larger scale than any of its predecessors.

It appears that M. Broca, director of the Compagnie des Tramways Nord, was the promoter of the undertaking to which we have referred on previous occasions. The Société du Travail Electrique supplied the batteries, maintains them, and guarantees their efficiency; and Messrs. Averly, of Lyons, the cars and motors; whilst Messrs. Garnier erected the steam plant. Each firm is responsible for the material furnished. The conditions imposed upon the contractors were to substitute accumulator cars capable of accommodating 52 passengers, of travelling at 7·5 miles an hour, with a possible speed of 10 miles in the outskirts of the city, 3¾ miles an hour on gradients of 40mm. per metre; the haulage, if necessary, of a separate car by the motor car, and a daily service of 84 miles per car.

The generating station contains two boilers, supplying steam to three engines, each of 125 h.p., and provided with horizontal cylinders and Corliss valve gear. One of these engines drives by belting a 60-kilowatt Desroziers dynamo running at 160 revolutions a minute. The other two engines, actuated at 70 revolutions, operate by means of countershafting two dynamos of the same type. The generators give 230 amperes at 260 volts, and are connected in parallel to omnibus bars on the distributing board. Each battery is connected to this board through a special circuit, comprising an ammeter, an indicator of the direction of the current, a cut-out, and a switch. The benches upon which the cells rest are

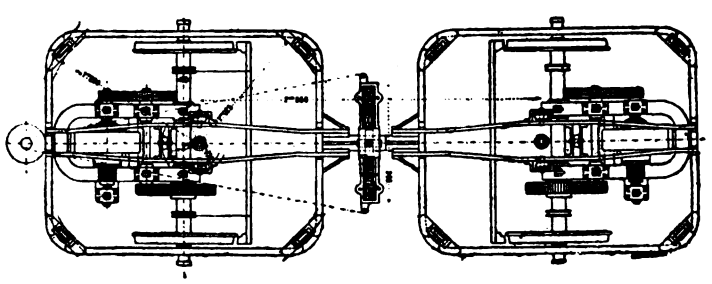

FIG. 1.

formed of tarred joists supported by brickwork, the cells being carried on glass insulators. These tables are provided with contacts, between which the batteries are arranged so that they are all coupled in series. The batteries are conveyed to and from the tables by means of small wagons, and they automatically make contact when placed in the cars.

The car body, as will be seen from Fig. 1, is carried on two trucks, and the motors each drive one axle by double-reduction gear, the ratio being 12 to 1. The motor is fixed on the one hand to the axle, and on the other to the frame. The motors are bipolar of the Manchester ring armature type, and are excited in series; the brushes are of carbon. According to the speed, the motors are operated at a pressure capable of reaching 200 volts; at 1,200 revolutions they give 19 h.p.

The battery, which is arranged under the seats of the car, comprises 108 cells carried in 12 ebonite boxes. They are connected in series, and each terminal is led to a small copper bar arranged on the sides of the box. Brass plates arranged on springs in the car are connected to the motor circuits by means of a coupling switch. Fig. 2 shows diagrammatically the connection of the switch. The brushes when fixed on the motor commutators are immovable; the reversal of the rotary movement is effected

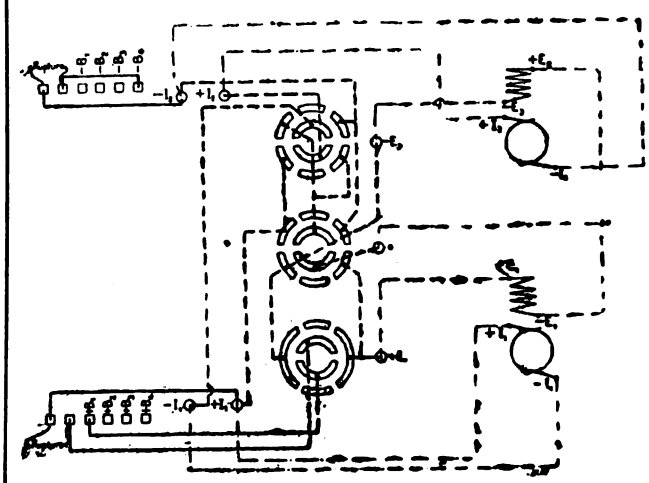

FIG. 2.

by reversing the direction of the current in the magnets. Each car then contains 12 boxes arranged in four groups, each having 27 cells in series, and which corresponds to a difference of potential of about 50 volts on closed circuit.

From the point of view of the energy to be consumed, each car has six parts: two motors, connected in series or in parallel, according as may be required, and four groups of batteries, which can be coupled in different ways to meet the requirements of the service. The motors are connected in parallel for high speed and in series for low speed.

The switch allows of being obtained the combinations indicated by the diagram given in Fig. 3: first, the four

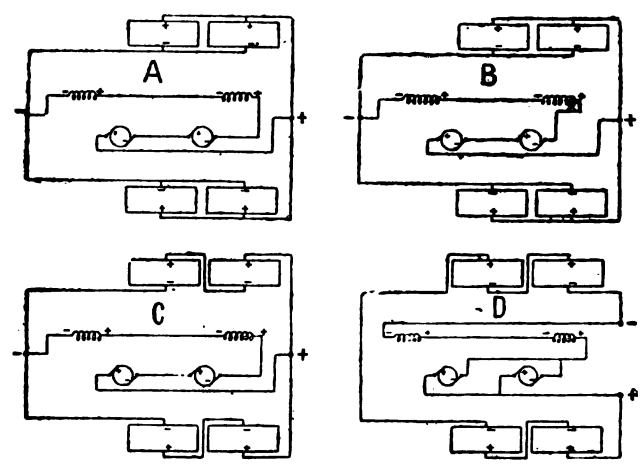

FIG. 3.

groups of batteries arranged in quantity, the E.M.F. 50 volts for starting, and a speed of 2½ miles an hour. The rings and the inductors are in series. With the same grouping of the accumulators, the inductors placed in series and the rings in quantity, the speed can be raised to 3·72 miles an hour. Second, two groups of sub-batteries in quantity and connected in series give an E.M.F. of 100 volts. Third, the four sub-batteries in series yield 200 volts. The speed of the car varies by changing from one method of connection to another in the relation of 1 to 2.

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By the aid of the Fig. 3 and the cross-section and elevation given in Figs. 4 and 5, it will be easy to understand the various operations of the switch. On the upper partition of the box containing the cells is arranged a hand-wheel, provided with three handles. The working of the hand-wheel brings about the different ways of connecting the batteries already mentioned. The terminals are brought to contacts formed of spring plates; the movable drum around its vertical axis effects the determined combinations.

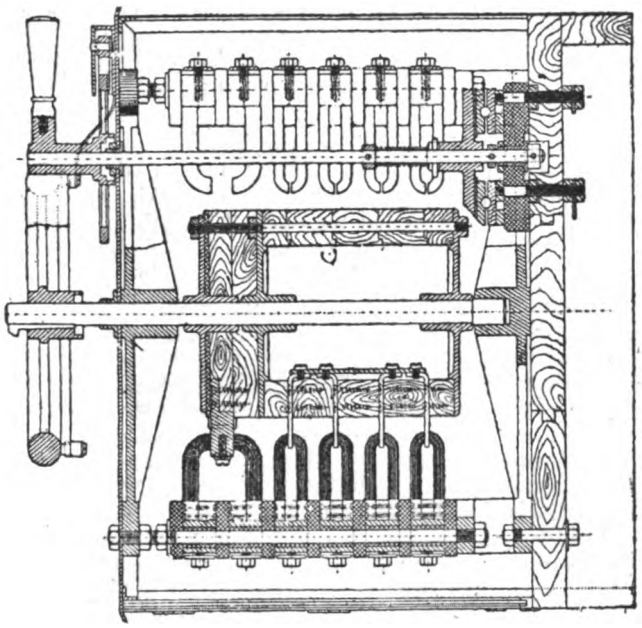

Fig. 4.

It is provided on its periphery with pallets, the insertion of which between the spring plates brings about contact. The upper disc gives communication to the motors. It is called the "rupture" wheel; its pallets are narrower than the others, but are much thicker, and are provided on the edges with two carbon plates, on which the breaking spark takes place. The wear is thus localised on these pieces, which are inexpensive and readily replaced.

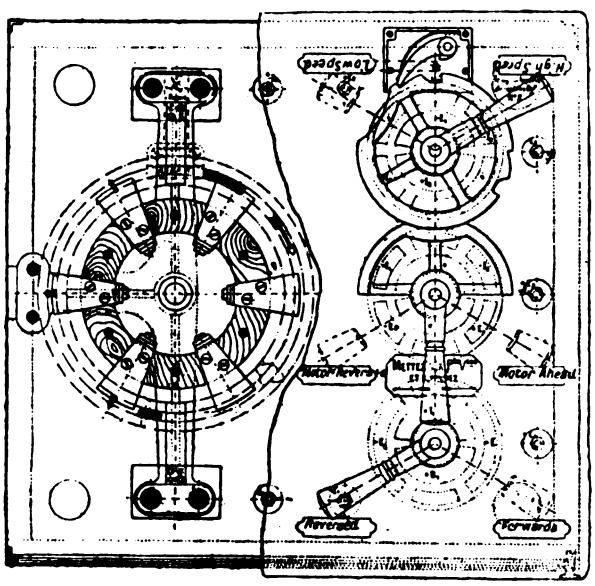

Fig. 5.

The second part of the apparatus, comprising the whole of the handles, serves to effect the coupling of the motors, the changing of the speed, and direction of rotation. The first handle, bearing the words "low speed," "high speed," allows of the connection of the motors in series or in parallel. It is connected to a wheel provided with two notches where a ratchet engages, and which prevents rotation from left to right. The rotation is freely possible in the reverse direction—that is to say, one can pass from high to low speed. To attain the high speed, it is only necessary to raise the ratchet. The second handle is used to cut out one of the two motors in case of accident. Before doing so the motor is short-circuited, and this can only take place if the motors are in series. It is at such a time necessary to be running at low speed so as to cut out a motor. The third handle is for the purpose of controlling the forward or backward movement of the car by reversing the current in the magnets.

The two tram lines worked by the storage battery cars have some steep gradients, and each car with a full complement of passengers weighs 12 tons. It is stated that the cost of working per kilometre run is ·53f. as against ·56f. for horse power—or, say, 8⅜d. per car mile for the electric cars.

THE COST OF ELECTRIC LIGHTING.

The managing director of the Crystal Palace District Electric Supply Company, Limited (Mr. George Offor), is to be congratulated for his energetic action in the direction of popularising the use of the electric light, especially in regard to its cheapness. We extract the following from a circular just issued by that gentleman:

"With the varying circumstances under which almost every individual uses the electricity, any opinions based upon the quarterly accounts of the company's customers must necessarily be more or less defective, unless the previous candle-power and cost of gas in each case could be compared with them. But one fact is very apparent—viz., that with experience in using the current the cost becomes less. And this is not only proved by the results obtained by thorough study and the exercise of great care in the management of the light, but the fact is also established by the returns of the supply companies, which show a reduction year by year in the annual consumption of electricity, and consequent cost, per 8-c.p. lamp installed. For example:

Electric supply companies.	Amount received per 8-c.p. lamp connected. 1891.	1892.	1893.
	s. d.	s. d.	s. d.
Metropolitan	13 7	11 1	—
London Electric	12 3	10 9	—
Charing Cross	16 11	12 5	—
Chelsea	8 4	7 7	6 8
Kensington and Knightsbridge	7 8	7 9	7 5
Notting Hill	8 2	7 3	6 6
St. James and Pall Mall	19 2	15 5	—
Westminster	12 7	9 7	7 9
City of London	—	14 10	13 5
House-to-House	9 3	9 0	7 10

The above results prove the gradual reduction in cost of electricity by economical using. The above districts of London (Kensington, Chelsea, and Notting Hill being residential areas of similar character to Sydenham and Upper Norwood) have about 600,000 lamps connecting with the companies' mains. The cost, however, may be arrived at very accurately on the basis of ¼d. per hour for an 8-c.p. lamp, when the charge for current is 8d. per Board of Trade unit.

Nature of premises.	Candle-power.	1893. Michaelmas quarter.	1893. Christmas quarter.
Private house	1,400	£3 7 2	£9 2 6
,,	1,218	10 7 7	14 3 2
,,	1,117	7 1 4	20 14 8
,,	768	1 16 0	7 3 4
,,	432	6 12 0	11 12 8
,,	352	1 3 6	7 8 0
,,	216	2 10 0	3 18 0
	5,503	£32 17 7	£74 2 4
Church	960	2 5 5	4 12 5
Shop	1,106	4 13 4	18 1 4
,,	1,084	28 12 8	45 13 4
,,	1,028	12 3 10	34 10 10
,,	576	4 4 7	9 12 10
,,	200	5 15 1	5 2 6
,,	160	1 0 2	5 2 9
	4,154	£56 9 8	£118 3 7

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The preceding statement compiled from my company's books shows the amount actually paid for the supply of electricity during a summer and a winter quarter (Michaelmas and Christmas) of last year, the cases cited being a fair average of the whole. Assuming the consumption for the Lady Day and Midsummer quarters to give similar results, the above return shows that the cost of each 8 c.p. of light installed would be 6s. 2½d. for private houses per annum, 13s. 5¾d. for shops, and 2s. 3½d. for the church."

MULTIPLE TELEPHONY.

At a recent meeting of the Vienna Electro-Technical Society, Mr. Nissl, of the firm of Cjeza and Nissl, read a paper entitled, "A Revolution in Telephony." The paper described a system of telephony whereby one wire can be made to serve several subscribers to an exchange. The principle of the method is stated to be as follows: At a certain point to which a single wire has been carried is arranged clockwork mechanism which causes a shaft to revolve. The speed of this shaft is governed by the number of subscribers' instruments to be served. For instance, in the case of four instruments the shaft would make a complete revolution in one minute. On the circumference of the shaft are arranged contact-pieces upon which feathers slide in such a manner that individual subscribers are brought successively into communication with the exchange for a short period; when the shaft is at rest the connection lasts. Each subscriber is enabled to arrest the rotation of the shaft at any moment when he is in communication with the exchange. Similarly, the exchange can stop the revolving of the shaft. The bringing to rest of the shaft is effected by means of a current passing through an electromagnet which actuates an armature, causing a catch to be inserted in the cogs of a spur-wheel. Arrangements are provided for indicating both to the exchange and to subscribers which contact is sliding under the feather. Further information on the subject is given in the *Zeitschrift für Elektrotechnik* of May 1.

HOW GARNESDON GOT ELECTRICITY.

It may seem to have been a very simple proceeding to those who knew Garnesdon about four years ago—very simple indeed. A company was formed, and an experimental installation was fitted up and successfully run for three months, after which permission was given to the company by the Local Board to light the public streets and supply private consumers.

That is all that seems to have occurred in connection with the successful flotation of the Garnesdon and District Electricity Supply Company, Limited, and if it were not that my conscience troubles me a little during my siestas here in Rosario, that is all that the public would ever know about it, more particularly as the late engineer to the company died a few months ago.

Four years ago I was just out of my time with a firm of electrical engineers, and on the look-out for a chance to add M.I.E.E. to my signature, and at last, in answer to an advertisement for "a young man with knowledge of practical electricity," I got work in Garnesdon.

It seems that the Local Board of that place had had a disagreement with the gas company, and being treated high-handedly, had secured a provisional order for electricity This kept the gas people in order for a while, and in the interim the surveyor and the members of the Electric Light Committee of the Local Board had been bombarded with the tracts and pamphlets of manufacturers of every article that could claim a smiling acquaintanceship with electricity, in addition to which martyrdom in the interests of the community they had felt it only their duty to accept as many invitations to visit central stations and factories as could conveniently be managed, which is a very thirsty and exhausting process, as is well known. The Local Board were a trifle shy about making use themselves of the order, so, as soon as the hospitality of the electrical profession began to wane, the order was turned over, with the consent of the Board of Trade, to a company which had been formed with this result in view. The terms of the transfer included a proviso that the three months' trial should be successfully gone through before the complete ratification of the transfer. This was at the instance of the chairman of the Local Board, who was connected with the gas company. The electricity company thereupon offered to perform the trial upon his own premises, confident that good workmanship and careful operating would convert even a gasman. The offer was accepted, and the immediate result of the negotiations was a first-class dinner to celebrate the first stage of the transfer given by the company to the Board and its wives.

When I came on the scene a week or two after, I found the work of altering a mill on the bank of the river into a central station well in hand. The engineer to the company was a practical mechanic and had a good working knowledge of electricity. He got out the plans of everything, arranging to have the machinery run by turbines, which replaced the old mill wheel. A consulting engineer verified his calculations with regard to the electrical plant, which he had chosen with a view to the utmost simplicity in working. The turbines would drive 110-volt alternators, the current from which would pass from the omnibus bars into low-tension mains for houses in the vicinity of the station, and also into a step-up transformer at 2,100 volts for feeding banked transformers placed where distant groups of houses would require current. House transformers would also be used on this circuit, where the demand was scattered.

I did not find my new e[illegible]h of a sinecure at first, for the board of directors ha[illegible]as and wanted dividends. All the company's shares [illegible]taken up by the board and its immediate rela[illegible]had not been offered publicly. The consequen[illegible]as that the engineer and I became temporarily h[illegible]and wielded shovels, trowels, files, and all the other pretty toys necessary to the erection of an electricity works until the machinery began to come in, when the more congenial task of correctly adjusting it became our lot.

It will been seen that the company was very sure of securing the ratification of the transfer, as, in addition to the elaborate preparations at the station, they had decided to lay the mains underground to the chairman's house. This would, of course, be best for a permanent job, but a much heavier debt would be incurred in the event of the withholding of the transfer than if overhead wires had been used. The conduit consisted of two ducts 2½in. square upon the "Johnstone" system; the high-tension feeders would be drawn into one of these ducts and the low-tension mains into the other. For the present iron drawing-in wires were laid therein, as the cable had not been delivered. There had been a little controversy as to the preferability of twine for this purpose, but it was finally decided to use No. 12 wire, and drawing-in boxes were put down at 100 yards intervals.

The chairman's house was about half a mile off, and was to be lit during the three months' trial without using transformers, this course being considered safer, and the high-tension $^{7}/_{15}$ cable was to be used for the transmission, being plenty large enough to carry the current for the 50-light installation. Everything, at last, being near completion except the wiring of the house, I took that in hand, while the engineer got things shipshape at the station.

My job was a very pleasant one. The household consisted of Mr. Rogers, the chairman of the Local Board, and Evelyn, his daughter, together with an aged housekeeper and the servants. The daughter was a sweet young thing of about 20 and seemed entirely free from the affectation that prevails so generally among women of the middle class. This probably could be accounted for by reason of her mother dying while she was yet a baby, and she had therefore to read the world chiefly through her father's mind; a man, of course, having less finnicking ideas about things than a woman, especially a middle-class woman. The lack of the maternal control could be seen, too, in the whirlwind-like way in which she went about the house. One day I had just started on the drawing-room and was at the top of a ricketty step-ladder behind the door with joy in my heart and in my mouth many nails, when an invisible force com-

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municated to the door sent the ladder to the other side of the room. I went as well, and performed the latter half of the journey on my head.

When I came to, the housekeeper and Miss Rogers were picking the nails out of my tongue and gums while the servants were standing around with wide open eyes. It was very pleasant for me, especially when the nails came out easily, and I lay there till they were all extracted, listening to words of sorrow and apology from the Rogers girl. I couldn't say much in reply for a long time, by reason of a crucified tongue; and when it was at liberty my efforts at pronunciation were so realistically similar to the immediate effects of a champagne supper that I hailed the doctor's advent with relief, and was straightway ordered off home to go to bed and poultice my mouth.

Next day I felt all right, so started work at the house again. Half-way through the morning a dainty rap sounded on the door. I climbed down hastily from the ladder and opened. The whirlwind was there, looking more like a penitent zephyr, however.

"I am so sorry to have hurt you yesterday," she said. "It was so thoughtless of me not to remember that you were in the room at the time. I hope you are feeling better to-day."

I said something about the pleasure of being made a nine-pin of occasionally, and that she was very kind to risk her fingers between my teeth after the nails.

"And that is what I want to speak to you about," she continued. "Why on earth do you put nails in your mouth?"

I explained that the average man being only possessed of two hands, it had become fashionable among wiremen to utilise the mouth, so as to overcome this lack of foresight in the design of mankind.

"But I'm sure they must taste nastily. Do you wash them first?" she asked.

I assured her that a self-respecting wireman washed his nails morning and night—I did not specify the brand of nails—but promised in future to carry them only in my pocket, to prevent accidents.

After that we used to chat together very often when her father was out. It was well known that he wanted the light to fail during the trial so that he would have a good excuse for withholding the confirmation of the provisional order's transfer; consequently, he did not waste civilities upon myself. But his daughter was very nice, and took an absorbing interest in every item of the work, from the connection leads to the last lamp, and she saved me a lot of trotting up and down ladders to get tools and things. Sometimes she would get inquisitive concerning the inner workings of apparatus and the reasons therefor, whereupon I would stay my hand in its work, sit on top of the ladder like a heathen god on its altar, and tell her all I knew about it. If the day was sultry, the explanation would become very minute and of a Münchausen character; but even on days when the spirit of industry was at its strongest, the sight of a fair maiden, leaning against something that matched her dress and drinking in with upturned face the words of wisdom that came from the topmost rung of the stepladder, was enough to make the description of even a humble ceiling-rose a theme which could not be dismissed under an hour and a half. Oh! it was very nice; and perhaps if the housekeeper had not frequently found excuses for Miss Evelyn's presence elsewhere, I might have been still on that stepladder declaiming the virtues of cut-outs and double-break switches. I noticed then, with sorrow, that old Rogers was extremely unreliable—with regard to returning home, I mean—and could never be absolutely depended on to turn up within an hour either before or after the time at which he was expected. There were some very near squeaks sometimes in consequence of this, but usually when he came round to inspect progress my hammer was making the house echo and the piano was making the hammer feel ashamed of itself.

All jobs, even 50-light jobs, must come to an end at last, but it couldn't be helped under the above conditions and with the unfeeling engineer on pins to start his machines. If it had not been for the vital importance of the trial, I fancy that the cut-outs in the house of Rogers would have needed pretty frequent repairs; but I nobly withstood the temptation to put weak fuses in, and thus risked the chance of not seeing so much of Evelyn.

However, fortune favours the virtuous, and it was a weird day during the next few months that we didn't manage to run across one another "quite promiscuous like" on the high road or in one of the pretty meadow paths in the vicinity. Old Rogers was understood to be very wroth when these meetings reached his ears, but his daughter had a will of her own and— well, perhaps he knew her better than I did.

As soon as the house was finished and the last connection made to the station switchboard, we saw all clear in the dynamo-house, put a tub of salted water into the circuit, and opened the turbine gate. The main switch at the house had been previously closed, so that we had just the line and resistance in circuit, and great was our joy to find the voltmeter finger point to 110 as we gradually lessened the resistance. Next day the trial commenced in earnest, from sunset to midnight, as agreed upon, and everything ran sweetly.

It was very easy work now, and would be till the end of the trial, when, if successful, we should put down two more 25-kilowatt alternators; mains would have to be laid throughout the compulsory area, and transformers put down—one at each side of the upper town and three in the lower.

One day I persuaded Evelyn to visit the works, and introduced her to the engineer, who showed her all over the place and quite eclipsed the glories of her scientific experiments on making switches spark at home, by letting her work the adjusting screws of an arc light frame which he had put together while we ran the exciter on to its terminals. After that she often dropped in, and learnt the names and uses of everything in the station. She was very useful, too, at times; when an instrument would require tinkering up, her delicate fingers would make short work of what to either of us would have been a most sweatful and laborious job, provocative of free and easy blasphemy. In fact, she got so eaten up with the attractions of the works that we had to keep our eyes perpetually on her to prevent her from opening the turbine gate when the machine was on dead short-circuit or from making impossible joints on spare cable, which process stained her dress and ruined the whiteness of her fingers.

All went well at the works for about nine weeks. No complaints had been made of the light not being bright or of it flickering, which was not very strange, even when old Rogers played the goat with the big electrolier switch, evidently to try and jerk something wrong, as Evelyn would tell us; we always ran the alternator at nearly its maximum speed, and the excess current went into the salt-water tub, which was an effective deadener and cost us nothing more. We got so cocksure of ultimate success at last, that we sometimes dispensed with preliminary runs before sunset and only started our machines when twilight came. This only happened if we were both away during the day, as sometimes happened if there was something on in the neighbourhood such as a picnic or an agricultural show, when we would lock up the place early in the day and get back before sundown. In fact, it was so deadly slow just then that we may be excused for getting out of sight of sleepy Garnesdon occasionally. There was little to do beyond testing the machinery and the circuit, and this duty was usually performed about mid-day, and was sometimes witnessed by members of the Local Board passing at the time. Old Rogers, the chairman, often looked in during these operations and picked his teeth meditatively. Once he dropped his silver toothpick near the alternator and the engineer swore that he tried to drop it into the field, and ever afterwards kept a wary eye upon him.

One day a grand Primrose League garden party was to be given at Storton, about 15 miles away, which was the event of the year. People came to it from all parts of the county, but it was very select. Evelyn had told me that she was going, but that her father would have to go to London that day. This was maddening to me, who, of course, had not been invited. The engineer's best girl was also going, and as her parents were not sure of accompanying her, it was likely that the two girls would drive down together. Consequently the engineer and I were in a very vicious state of mind, and on the morning we awoke with heavy hearts rather earlier than usual. I went to my window to see if our charitable prayers for wet, streaming, dismal weather were going to be answered, but was disappointed. The early morning sun was shining with a stolid German perseverance that betokened a cloudless day. Coming down the road was Mr. Rogers,

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with a bag in his hand, looking very flushed and heated, and evidently on his way to the railway station. No one else was in sight as far as I could see from behind a crack in the blind. Within 20 yards of the works he stopped behind the hedge and wiped his perspiring face with his handkerchief and then fanned himself vigorously. I still watched curiously; it was such an odd thing for a man to do after a five or ten minutes' walk from his house. At last he resumed his journey, evidently feeling less heated, but instead of passing on he went to our gate and pulled heavily at the bell. I slipped on a dressing gown and went downstairs wondering what could have happened to the light the night before. He was just giving the bell another tug and seemed surprised at my prompt appearance.

"Good morning," he said. "You sleep lightly, young man. I've got some spare tickets for the Storton garden party to-day, and if you and your chief would like to attend it you are welcome to a couple."

I thanked him with fervour, and he continued: "My daughter and Miss Hearne are going down in the trap, and as it might be awkward for you to get there by yourselves, you have my permission to drive them down. You or Mr. Holloway can drive, I suppose?"

I said "yes," but I meant dynamos.

"Well," he said, "don't start later than nine or you'll miss the luncheon. You can return in the trap when you please for your duties here and have it sent back for the ladies."

I was redolent with gratitude and invited him inside to endure the pouring forth of similar sentiments from the engineer.

"No, thank you," he replied. "I only just have time to catch my train. Hope you'll have a pleasant time; you hard-working fellows deserve it. Good-bye," and with that he was off.

The engineer had heard the conversation, and when I burst into his room had forsaken dignity and bedclothes, and was standing on his head.

"Well, I'm blowed!" he exclaimed, finally resuming the respectability of the horizontal plane. "I never credited the man with being anything better that a pirate with a pretty daughter. My conscience, won't we enjoy our young selves?"

I told him of the long time old Rogers had stayed outside before calling, and how inexplicably hot he semed to be, but the only conclusion we could arrive at was that he had had to call somewhere else after leaving his house, and was perhaps too regardful of his dignity to call upon us in his then state of towzled perspiration. At any rate we hadn't much time to waste talking, and our looking-glasses were pretty busy during the next half-hour or so. Breakfasted as usual at the King's Arms, and started for the house in good time. The girls were both ready, and off we went: the engineer and Miss Hearne on the box seat and Evelyn and myself behind.

Of the beautiful time we had that day it is not necessary for me to speak. The programme thereof may sufficiently indicate it. Luncheon, tennis, tête-à-tête, dinner, croquet, tête-à-tête, refreshments, boating, tête-à-tête. Then it was time for the engineer and myself to come away; the more especially as Evelyn had told us that a little dinner party was to be held at the house that evening, and the lights would be coming on early. Her father had told her to please herself about attending the dinner, as it was a purely masculine gathering, but she decided to return, as did Miss Hearne, which was so much nicer for us two men.

The return journey was too soon over; we dropped Miss Hearne at a house just outside the town and drove straight through to the works, as Evelyn wished to see the machinery started. It was only about half-an-hour to sunset, and as we approached our destination we noted the rustic beauty of the immediate neighbourhood of the transmogrified mill, the dazzling glory of the setting orb, and the general peace and quietness that prevailed. The engineer waxed cynically practical; "It's a good job for us the sun does set sometimes," he remarked, "precious little electric light would be wanted if it didn't."

Evelyn said that he reminded her of a depraved man her father knew, who built fire-engines and saw no beauty in other than wooden houses.

When we got to the works we were nearly stifled by the heat inside. The baking sun had been pouring down on the roof of the dynamo-house all day, and had converted it into a first-class oven. We opened the windows and sat down by the switchboard. Evelyn said, "I *should* like to start your machines to-night. I'm sure I could manage it all right."

Evelyn's desires were usually laws to us so, though it was too early to start, I went to the sluice valve and polished the wheel with some waste, adjusted the resistance for no load and stood by while she screwed the valve wheel round slowly, watching with evident delight the gradual revolving of shafting and increasing hum of the alternator and exciter.

"Whoa!" suddenly shouted the engineer rather impolitely. "Turn it back, quick!" You'll burn the blessed things up!"

I looked around. Sure enough the armatures were revolving at an alarming rate, and yet the valve wheel was not sufficiently unscrewed to account for this. Evelyn reversed the wheel and we looked at the voltmeter, which read *nothing!!* This was strange, since even then the tachometer was reaching 150, and I went round to all the connections and switches to find the cause of this open circuit. Everything seemed right, and, in response to my look of enquiry, the engineer whistled the ⌒⌣-like whistle of a man in doubt.

"Do you think that your man has forgotten to close the main switch at your house?" he asked Evelyn, "or perhaps he has opened it too soon?"

"I don't think so," she replied; "Henry is such a methodical man. But I will drive there and see."

"Thank you," said the engineer. "You had better go, too, Tom, and see if the fault is at that end of the line. Make haste back if it isn't."

I helped Evelyn into the trap, and we drove at a breakneck pace to the house and went through the side gate to the switchboard shed. The switch was closed, as we had arranged to always have it during the day to enable us to test the line properly, and the ends of the cable were securely sweated into the thimbles at the back! A hasty glance assured us of both these facts, and a growing conviction that the trouble was on the line forced itself upon me. Evelyn grasped the situation immediately, like a true woman.

"Come back to the works," she exclaimed, "and see what is to be done"; and we got into the trap again and went back at full gallop.

Evelyn was quite as excited as I was, and seemed to realise as plainly the probable consequences of a non-supply of the light.

"I hope you will find what is wrong," she said. "Three of the men coming to dinner to-night are on the Local Board, and two of the others are connected with the gas company—directors, or something; and you can imagine what they will say if the light fails. Even if you never have another accident in the three months, the possibility of such a thing happening will be apparent to them, especially now when all is in your favour at the works."

I groaned inwardly and cursed the Primrose League, and all that therein is, which had led us away from the path of rectitude and of regular machinery testing. The horse would have cursed the Primrose League, too, if he could have traced to that body the reason for the wild slashing he got till the works were reached.

"Well," anxiously enquired the engineer, who was waiting outside; "anything wrong at the switchboard there?"

"No," I answered; "it must be a break on the line, I'm afraid."

"My conscience! A break on that 2,000 meg. concentric! Not the sign of a leak yesterday, was there?"

"Not a scrap. Shall I go out and try to find it?" I asked him.

"I don't fancy there's time," looking at his watch and then at the sun setting through the trees. "Even if you found it immediately, which there isn't much chance of doing, it would take you the best part of a day to make anything of a job of the thing. Must be a pretty clean break, you know, or part of the outer concentric would have given us some kind of return."

"And we haven't got a piece of spare cable over 20 yards long," I said, after rumaging through the storeroom. "We should just have time to run it over the fields to the house if we had; though it would not help matters much if Mr. Rogers got to know that we had to use makeshifts."

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Evelyn had been peering in among the stores, too. "Why won't that do?" she asked, pointing to the length of drawing-in wire which had been coiled on a drum after being used to get the cable through the conduit. I was about to explain to her in a superior masculine manner that it wouldn't carry the current, when the engineer said, *con expressione*, "By Jove, the girl's right," and straightway got out his pocket-book and began figuring rapidly therein.

"There," he said, at last, "we'll fix the thing yet; but first, Miss Evelyn, can you tell me if there would be any chance of making a fresh connection to the switchboard at your house and of putting down one of those transformers there," pointing to a recently-delivered batch of house transformers, "without your father hearing of it?"

I saw his point now, and felt inexpressibly relieved when Evelyn promised to keep the servants out of the way at the house while things were fixed up in the shed. We should have to trust to luck not to meet anyone on the way.

"You're a dear girl," said the engineer, evidently relieved, and then he unfolded his plans to us. The step-up transformer, which luckily had arrived, would transform the voltage to 2,100, and the drawing-in wire would carry nearly two amperes without risk of undue heating. As only about 1,700 watts was the maximum power that could be taken by the house, and 1,200 a strong average amount, there seemed every reason for thinking that the arrangement would work out all right in practice.

We had no time to lose now, so set to work to mount the drum on a truck, with the transformer on a board between the shafts, and Evelyn set off for the house to get things ready for its reception. We fastened one end of the wire to a tree at the side of the works, and then, no one being about, the engineer trailed the wire along the top of the parched hedge while I pulled the truck along. Although there were a great many twists in the road, there was not a break in the continuity of the hedge except for an occasional stile, a series of meadows being between the works and the house on that side of the road and a few big houses on the other. We got along splendidly till within a short distance of the house, when we found that the wire would hardly be enough, if we followed the course of the hedge, on account of the windings of the highway, so we decided to cut across the meadow to save going back for more wire. We had to wait five precious minutes, however, while a loving couple meandered down the road one behind the other, after the approved style of those in humble life whose love is too deep for words. We cursed them in our hearts as they stared foolishly at the truck and at the engineer on the other side of the hedge with a sack cast over the drum, and felt relieved when they had gone out of sight round a bend trusting they had seen nothing incriminatory to gossip about. Then we laid the wire along the grass, propping it up with twigs as we went, though the grass itself was dry as tinder after the heat of the day. The end of the wire we threw over the side wall, as near to the shed as we could judge, and then returned to the road, the engineer to return to the works to fix up things, and I to take the transformer to the side gate, where Evelyn was waiting anxiously. By the interest she was taking in the swindle one would never have thought that she was helping to undermine her father's business, and, of course, do no good to herself financially. But then she was a woman, you know.

No one was about, so I got the transformer into the shed safely and brought the end of the wire in through a crack in the roof. Evelyn became jubilant. "I have told Henry that I've opened the switch," she said, with an unaccountable pride in the success of the lie, "so he won't come out here to-night. Can I help you?"

I did not need help to disconnect the house wires from the switchboard, twist them to the low-tension side of the transformer, and the drawing-in wire to one of its high-tension terminals, but I was rather puzzled and anxious about making a good enough earth. When, however, I told Evelyn what I wanted, she showed me the earthed end of the lightning conductor, and that job was soon over.

Before I went back to the works I wilfully wasted a couple of minutes telling her what I thought of her goodness and devotion to our cause, what my friend the engineer thought of it, and what all right-minded people would think of it if ever they got to know. In fact, I should have stayed there all night babbling gratitude if she had not reminded me that the engineer might want me, and that we were not yet out of the wood.

I tore myself away and hurried back with the truck, pleased to observe that the wire was almost invisible on the hedge and calculated that it would be entirely so after dark. I found the engineer connecting a cable from one of the dynamo brushes to a choice collection of pickheads and crowbars that he had driven deep into a shallow pool at the rear of the works, and to the other brush was connected the drawing-in wire. I told him how things were situated at the house.

"Well," he said, "as long as the night keeps dry I don't think we have much to fear, but heaven help us if there is much of a dew or it rains. Mica hedges wouldn't be any good then. And, another thing, if anybody goes through that hedge to-night, there'll be the other after-world to pay. Still, we must risk it now."

I agreed with him; we were so wrapped up in the affair and the hope of its successful termination, that I half believe we would have risked our immortal souls to bring this about.

The sun was well below the horizon now, so after seeing everything in order and hastily muttering a prayer to the *deus ex machina*, the machines were started.

To our joy the voltmeter finger moved around the dial as the sluice valve was opened, and with a heavy artificial resistance in circuit stood at 102. When the resistance was reduced the machine gave almost its normal output, so that we had no fear of having to overrun it and risk the armature coils. After a time the load began to come on and I went outside to see how the wire bore it. There was no apparent heating, a light breeze keeping the temperature down. Then, as the engineer had things well in hand, I took a couple of hooks and commenced an inspection of the road boxes, of which there were eleven between the house and the works. It was hard work getting off the covers single-handed; dirt had been wedged in which, with the red lead packing and the weight of the cover itself filled in with concrete, made me appreciate the evening breeze. At nine of the boxes I could find nothing to indicate a break in the cable, and as it was now quite dark I began to fear it would have to be a hauling out job. When I tackled the tenth box, which was situated at a kind of double bend in the road close to the house, it came up very easily, nearly throwing me backwards on my head. I struck a match and looked inside, and a glance explained the loose cover—and several other things eventually—for the cable had been rudely hacked asunder just where the conduit entered the box. There could be no doubt but that it was an intentional deed. The works' end of the cable hung over the hedge of the conduit, but did not touch the bottom of the box.

I sat down with my legs in the box, trying to think who had done this, but had to give the puzzle up at last, and was cogitating ruefully what a deucedly awkward thing a concentric was to splice, and how doubly deucedly awkward the operation would be if there was not enough slack to enable it to be got at properly, when I heard someone coming along the road. I did not move till I heard the footsteps stop, and then quickly retrace themselves, and when I looked up the owner of the feet had disappeared around the bend again. I thought it very strange, but concluded that it was some timid person who saw me sitting in the road, and took me to be either an accident or a highwayman, and after a few minutes' meditation I got up and replaced the cover. Just as I was stamping it down, I heard a hoarse, quick cry seemingly not far off.

"My goodness," I thought, "if it's anybody messing about that hedge," and ran in the direction of the sound. There was no one in sight down the road either way, so, as the hedge was very thick, I went for the nearest stile, and looked into the field. Some little distance along, close to the hedge, I could see the form of a man lying down, and as I drew near I went sick with apprehension as I recognised the spot where the wire branched off from the hedge across the field. This, and the contracted posture of the body, made me fear the worst.

Before touching him I ascertained the whereabouts of the wire, and found that he had evidently stumbled over and beyond it in his fall. I stepped cautiously over it and turned the man on his back, realising my morbid expectations. The

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man was dead! And as I bent over him I recognised the features of old Rogers.

At first I would not believe my eyes; the facial muscles had contracted, a froth had issued from the lips, and the semi-darkness may have deceived my physiognomical memory, but there was no mistaking the inevitable black bag and the massive gold chain with the cross and locket dangling therefrom. I think I may say, with some degree of truth, that the unfortunate event somewhat awed and perplexed me—perhaps because I was younger then. Why was old Rogers behind the hedge at that time of night? and what was to be done in the present state of affairs?

A dim, religious light began to dawn upon me with regard to the first problem. From the position of his body, he was evidently returning to his house from the railway station. Could it be that his were the footsteps that retraced themselves at the bend of the road a short time previously, and had he then got over a stile and walked noiselessly along the field, past where I was sitting in the road, till he came in contact with the deadly wire as it left the hedge? And if so, what was the reason for this strange proceeding?

There seemed only one way to account for it; ordinary timidity did not fill the bill. A guilty conscience needs no accuser, and he had evidently recognised me sitting in the road box where the broken cable was, and had avoided meeting me. Now I saw why he had come down the road to the station in the morning flushed and heated, and had waited to cool off before seeing us; why he became so suddenly generous with the garden party tickets; and as I picked up his bag, which was securely locked, and shook it, the weight and the muffled jingle of metal inside told me plainer than a provisional specification could have done in a month that a hammer, cold chisel, and perhaps some kind of appliance for lifting the lid of the road box, were wrapped in newspapers inside. That settled me in my resolve to let his death remain as much of a mystery as possible, and I stepped back across the wire and made for the works. The wire as it passed the stile had been carefully hidden out of sight and easy reach, so that there was no danger in crossing it. I passed a few people on my way back, but felt sure that no one could see the body from the road.

"Found the break?" queried the engineer, as I came panting in.

"Yes," I replied; "and the breaker."

"Good business; let's hear about it."

I sat down and explained the state of affairs. The engineer's eyes opened and his face grew longer in orthodox manner as the tale of woe proceeded. "Shall we go to the police station and give ourselves up?" I asked in conclusion.

"Not much," said the engineer, after reflection; "it's just a judgment of Providence on the man. I don't think we need say anything about it."

"Don't you think the doctors will find out the cause of his death at the post-mortem? Providence doesn't own an electricity works in Garnesdon, you know."

"We must chance that," said the engineer; "besides it is very unlikely that the small current could do all that mischief. He was subject to fits or something internal, wasn't he? and probably the shock just helped one along."

I remembered Evelyn telling me that her father suffered from heart disease, so that cheered us up a little. "How rummy the place looks, lit with lamps and candles," I observed.

The engineer smiled too. "Yes, I was afraid to tinker with the circuit to-night to light us up here. By the way, the voltmeter gave an odd jump about twenty minutes ago, but I thought it was the big electrolier switch being played with. It must have been poor old Rogers giving up the ghost. I shall be glad when twelve o'clock comes, and we can take that wire in out of sight," he mused. "Wonder what the guests will think of his non-appearance, and if his plucky little daughter will guess what's happened."

I felt very sick, for Evelyn's sake. Believe me, it is never nice to discover oneself to be a murderer, and the unpleasant feeling is in no degree modified when the murdered man happens to be the father of the girl one loves. This unfortunate mental condition will prevail even when strong extenuation exists in the fact that the deceased was an electrophobian gasman.

And if Evelyn did discover how her father met his death, I suppose that I should have to feel very sick for my own sake; unless, indeed, she reciprocated the affection I entertained for her to a greater extent than at the time I thought possible. These thoughts and occasional attention to the machinery helped to pass the time away.

About ten o'clock a vehicle stopped outside, and the engineer rushed to the door, unwilling that anyone should come into the station in its present condition, shut the door after him, and went to the outer gate. Some conversation ensued with the occupants of the trap, and then it was driven off. Presently he came in again.

"They've missed him at the house," he said. "The guests got tired of waiting for him to turn up, so dined with the two ladies and looked in here on their way home to see if we had heard anything of him. They fancy he must have been detained in London, but the housekeeper thinks he has had a touch of heart disease; and that's how matters stand to the outer world at present. I don't think they are likely to take any steps till the morning, and in the meantime we can get that wire in out of the way."

Midnight came in due course, and we shut off. I went up the road to the house and cut the wire outside the garden wall, intending to call in on the morrow and remove all traces inside the place. As I returned, coiling the wire up, I found the engineer bending over the body, examining it.

"See where it touched him," he whispered; "just on the back of the wrist. He must have been stooping pretty low at the time, and the shock made him jump right over it. Funny-looking brown mark, isn't it?" as he struck a match to see it clearly.

We turned the body over into its original position and came away. Not a soul was out at that time of night, and we got the wire all in and went to bed worn out with the events of the day. Neither of us slept much that night, and we got up early in the morning to prepare our jointing and vulcanising tools, expecting to hear every moment of the discovery of the body. The road was not a very much frequented one, and it was nearly nine o'clock before a man came rushing past on his way to the town. Ten minutes after, a cab containing a doctor and several policemen tore back towards the fatal spot, the loafers of the town bringing up the rear, eager to gratify that pardonable curiosity which helps to distinguish mankind from the lower animal world. We carefully enquired what was the matter before joining in the rush, but when we arrived at the scene of the tragedy the body had already been carried into the house, and the late arrivals were growling as if they had booked high-priced seats to view the spectacle. The more fortunate ones described unctuously the appearance of the body, with elaborations, and said the doctor's opinion was that deceased had had a fit on his way home from the station the night before; and though the police were at first suspicious of foul play, in consideration of the peculiar situation of the body, they eventually came to the same conclusion on finding all his valuables intact.

Nothing more would be known about it till the inquest, but so far things looked as favourably for us as could be expected.

We did not feel like going to the house that morning, so trusted to the general excitement there that the shed would not be visited and set to work on the broken cable. Luckily, there was some slack in the drawing-in boxes on either side of the one tampered with, and, as the cable had been well greased when drawn in, we managed to haul enough along to make operations easier. People came up by dozens that day to view the spot where the body was found, which was guarded by a policeman till the coroner's jury should have seen it, and we had to rig up a tarpaulin shed to keep prying eyes from seeing too clearly the nature of our work in the box. The joint was finished that afternoon, though an experienced jointer at a shilling an hour would have probably taken a day over it.

Late in the afternoon I went to the house to proffer my sincere sympathy to Evelyn. She came down from her room on hearing who it was; her eyes red, but keeping up bravely. We only spoke about the sad bereavement at first, till, seeing that she had forgotten the operations of the night before, I enquired if I might go to the shed.

"Oh, yes," she exclaimed, her memory coming back to her. "I am so glad to say that the light was just as usual last night. Only once it seemed to go rather dull, but it was

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not noticed by any of the visitors. I hope you will find it all right in the shed."

I bade her good-bye for the present, and went out to the switchboard wondering what she would have said or done if she had known the cause of the light going "rather dull." The necessary disconnections were soon made, the end of the wire hauled into the shed and the transformer put in a corner ready for use, if required when the trial was over. Now that all trace of our operations had been destroyed and the circuit was in working order again, with the only man likely to destroy it out of the world, a successful ending to our endeavours seemed quite possible.

The dreaded inquest passed off very successfully—at least, from our point of view; though one of the doctors contended that lightning was the primary cause of death, heart disease supervening. No lightning, however, having been observed on the night in question, this opinion was overruled by the other doctors called in, who naturally enough preferred to attribute the effect to the most likely of doubtful causes, and the verdict was "Death from natural causes."

No one seemed to worry about the nature of the tools found in the black bag, and in due time the funeral came off and was attended by hundreds of people. All grades of sorrow were represented at the graveside—from the sorrowful sorrow of those who loved the man to the simulated sorrow of distant relations whose thoughts wandered away to the probable contents of the will—and, hypocrites though the latter were, they could have been safely given 50 points in 100 at that game by a couple of lachrymose-looking young men who were frequently convulsed by the effect of their own emotions.

After the ceremony we breathed freer, and slept at night for quite hours at a time. It was also possible for us to eat meat suppers again without being responsible for injurious effects upon the nerves of late wayfarers passing the station and of tramps who slept under neighbouring hayricks.

The provisional order was formally handed over to the company at the expiry of the three months' run, and now that district is one of the best lighted in the provinces. I see from the English electrical papers sent out to me that the total cost per unit is well within 3½d., so that it must be a good thing for the company at 7d. delivered. What it might have been if the late lamented chairman of the Local Board had caught an earlier train home on the night of his death, can only be judged by his actions earlier in the day.

As I have mentioned, the engineer is dead—got drowned in the river while in charge of the works, and I am here in South America.

Oh, yes, about Evelyn—I mean Lady Fitz-something or other. She found herself left so well provided for, and was so much sought after by the eligible aristocracy and needy nobility of the county, that—well, you know women, don't you?

PHYSICAL SOCIETY.

At a meeting on the 27th ult., Prof. A. W. Rücker, F.R.S., president, in the chair, a paper "**On the Mechanism of Electrical Conduction: Part I., Conduction in Metals**," was read by **C. V. Burton, D.Sc.** Considering a body not at absolute zero of temperature, the author shows that electromagnetic radiation would result in heat being degraded into a lower form of energy if any parts of finite electric conductivity were present, and from the fact that our planet is not devoid of heat deduces the following Theorem I.: "In a region containing matter there may be (and probably always are) some parts which are perfect insulators and some parts which are perfect conductors, but there can be no parts whose conductivity is finite unless every finitely conductive portion is enclosed by a perfectly conductive envelope." This conclusion is in accordance with Poisson's theory of dielectrics, and with Ampère's and Weber's theories of magnetism and diamagnetism respectively. Theorem II. is enunciated as follows: "In metals, and in other non-electrolytes whose conductivity is finite, the transmission of currents must be effected by the intermittent contact of perfectly conductive particles," and as a corollary Theorem III. is given: "If we suppose that in a substance at the absolute zero of temperature there is no relative motion amongst the molecules or amongst their appreciable parts, it follows that every substance at this temperature must have either infinite specific resistance (which does not imply infinite dielectric strength) or infinite conductivity." Fleming and Dewar's experiments on pure metals tend to confirm this. The author then shows why, on the intermittent contact hypothesis, a conductor is heated when a current flows through it. On the assumption that in ordinary conductors the relation between the electromotive intensity in the intermolecular spaces and electric displacement is a linear one, and that the electric forces are small in comparison with the ordinary intermolecular forces, Ohm's law is deduced. A model is next described, by means of which contact E.M.F. and the Peltier effect can be represented and explained; and in considering Volta E.M.F.'s, the author points out that it is doubtful whether experiments in a perfect vacuum could decide the questions at issue in the contact-force controversy. The fact that the transparency of metals is much greater than Maxwell's theory indicates might be explained without attributing any new properties to the electromagnetic field by supposing the dimensions of molecules not quite negligible in comparison with the wavelength of light. **Prof. S. P. Thompson** thought the paper had an important bearing on the kinetic theory of solids. He saw no reason why Ohm's law should be proved, for he regarded it as a definition. The **President** said the author represented all actions as being due to collisions, thereby introducing the same difficulties as were felt in the kinetic theory of gases—viz., that collisions would give rise to mechanical oscillations in the molecules of shriller and shriller pitch. After some remarks on the invisibility of molecules by **Mr. Hovenden, Dr. Burton**, in reply to Prof. Thompson, said Ohm's law when expressed as $\frac{E}{C}$ = a constant, was really a law, and not a mere definition.

A communication "**On the Design and Winding Alternate-Current Electromagnets**," by **Silvanus P. Thompson, D.Sc., F.R.S.**, and **Miles Walker**, was read by the former. The paper describes experiments showing that when the magnetic induction does not exceed 4,000 C.G.S., the pull exerted by a laminated electromagnet on its armature is the same whether it be excited by continuous or by an alternating current of equal strength. For higher induction the continuous current gives slightly greater force. Another experiment made with solenoids and the U-shaped plunger of a Brush alternate-current arc lamp, gave similar results. In considering the question of winding alternate-current electromagnets so as to obtain a given excitation when the current is supplied at constant voltage, it is shown that the ampere-turns are inversely proportional to the number of turns, for the impedance varies nearly as the square of the number of turns. One important property of such alternate electromagnets when supplied at constant voltage is that they give a fairly constant pull over a long range, for as the armature moves away from the magnet the current increases, thus counteracting to some extent the effect of distance. On the other hand, the alternating voltage required to obtain a given force is much greater than that needed with continuous currents. With the armature in contact with the core the ratio of the two voltages was found to be 170, whilst separating them by 9·2mm. reduced the ratio to 21·5. **Prof. Perry** pointed out that the constant pull of the alternate-current magnet followed immediately from the fundamental equation $e = re + n\dot{I}$, when re is small, for if e be constant, then $\dot{I}$ and therefore I and I^2 are constant. He was interested to see that the pulls for equal ampere-turns were the same, and indicated how the problem would be worked out mathematically when hysteresis was taken into account. **Mr. Blakesley** thought it better to fill well this space on a magnet full of copper rather than use wire only just large enough to carry the current, for the loss of energy would be reduced. Some of the formulæ given might be put in simpler form. **Mr. Swinburne** said an alternate-current magnet would only give constant pull in special cases. As another rule for winding alternate-current magnets, he said, wind the magnets as for continuous currents and put a condenser in to take the same current, thereby reducing the voltage required. **Mr. Blakesley** said it would require a capacity of 600 microfarads to suit the magnet mentioned in the paper. **Dr. Thompson**, in reply, agreed with Mr. Blakesley that the condenser was impracticable in many cases.

Major R. L. Hippisley, R.E., read a paper on "**A Graphical Method of Constructing the Curves of Current in Electromagnets and Transformers**," and exhibited a machine for drawing these curves. Taking the ordinary equation for a simple alternate-current circuit, $E \sin pt - \frac{dB}{dt} = Ri$, where B is the total magnetic flux, and i the current, the author writes it in the form $E \sin pt - mk L \frac{di}{dt} = Ri$, where L is the coefficient of self-induction of the circuit with the iron withdrawn, and mk the tangent of the inclination of the B H curve at the point corresponding to the instant considered. This equation is integrated for a short part of the cycle, during which m may be considered constant, giving $i = \frac{E}{R} \cos \theta k \sin (pt - \theta k) + Ak e - \frac{Rt}{mk L}$. Methods of finding the constants in the last equation are then described, and the method of drawing the current curves step by step explained. The machine for performing the process is illustrated in the paper, and the curve for an electromagnet fed with alternating current shown. The case of a transformer without magnetic leakage is worked out at some length, and the curves of primary and secondary current determined. **Dr. Sumpner** said the author had used great care in working out a difficult problem more completely than usual. In cases such as arise in practice, the R i term is small, and for this case Evershed showed how to determine the current curves of a transformer when the periodic state had been reached some five or six years ago. He (Dr. Sumpner) had also shown how to graphically determine the current curves for circuits containing iron in 1888. The author's method was, however, of more general application. **Mr. Trotter** enquired whether the machine could be used in practical alternate-current problems, say, for example, to pre-

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determine the E.M.F. curve of an alternator. **Major Hippisley** replied to the points raised.

LEGAL INTELLIGENCE.

DE LIVET v. OLIVER AND OTHERS.

In the Chancery Division of the High Court of Justice, last Friday, Mr. Justice Chitty had before him the action De Livet *v.* Oliver and others, in the shape of an application by the plaintiff for an interim injunction to restrain the defendants, until allotment to the plaintiff of 470,000 fully-paid £1 shares in the British Steam Generator and Refuse Utilisation Company, Limited, from selling, disposing of, or using the patent of the late C. de Livet.

It was stated that the plaintiff was the widow and personal representative of M. de Livet, who had invented and patented a means for burning and using refuse. Before his death, which occurred in August, 1893, he entered into an agreement with the defendants Oliver, Sheridan, and Houldsworth for the purpose of forming a company to buy and work his invention. After his death an agreement was made between the plaintiff and the three defendants and the above-named company for the sale to the company of the invention, in consideration of the allotment of the shares in question to the plaintiff, to be held by her in regard to some two-fifths thereof for herself, and as regards the remainder for other persons. In March, 1894, the defendants entered into an agreement with a syndicate called the Atlas Syndicate, for the formation of a subsidiary company for the purposes of taking and working a limited assignment of the patent within London and 20 miles round. The plaintiff stated that the shares in the original company had not been allotted to her, and claimed an injunction accordingly.

His **Lordship** said that the plantiff had a lien which she could enforce. He saw no reason for not applying the ordinary doctrine of vendors' lien. But, apart from that, it was agreed that she should have the shares at once. The plaintiff was entitled to an injunction as asked, until trial or further order, with costs in any event.

COMPANIES' MEETINGS.

SUBMARINE CABLES TRUST.

The twenty-third ordinary annual meeting of the certificate-holders in the Submarine Cables Trust was held last week at Winchester House, the Marquis of Tweeddale presiding.

The **Chairman** said the revenue for the past 12 months amounted to £22,593, as compared with £23,102 in the preceding year, showing a decrease of £509. This decrease was due to their having received a smaller dividend during the year from their investment in the Anglo-American Telegraph Company. He regretted to say that there was no visible improvement in the traffic on the Atlantic, and he feared that their income from that source was likely to suffer for some time to come. The expenditure for the year totalled £1,301, as against £1,627, showing a decrease of £326. This diminution was mainly owing to a reduction in the number of the trustees consequent upon the lamented death of their late colleague, Sir J. Anderson. The cost of administering the trust was £698 under the amount provided by the trust deed. The revenue during the past year was sufficient to meet two coupons of £3 each, and to pay an additional 5s. on the overdue coupon. There still remained £1. 5s. in arrear, which they hoped to pay in about July next. Although the traffic in the Atlantic was very low at present, they must hope that with a return of business it would improve, in which case their income would be in a very satisfactory condition. In conclusion, the Chairman moved the adoption of the report.

Mr. J. D. Pender seconded the resolution, which was carried.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.

The thirty-fourth ordinary general meeting of the West India and Panama Telegraph Company, Limited, was held on Wednesday at Winchester House, Mr. C. W. Earle presiding.

The **Chairman** said the result of the year's operations had been that they had received £4,093 less than in the corresponding period last year, and their expenses had been £2,553 less. As they were paying 3d. more on the ordinary shares, it might be asked how, seeing the net result was a reduction of £1,540, they could afford to do so. The explanation was that during the first six months of last year they had a windfall of about £2,000 by the interruption for seven weeks of their competitor, the French cable, between Hayti and Cuba. In the present half-year they had been able to estimate the outcome of the half-year, and, looking to the saving they would make from their second ship being in dock, and not costing more than about £400 a year, they thought they would be quite able to keep up the dividend on the current half-year as at present recommended. The Chairman then referred to the great advancement made in the code system, and said the West Indian merchant now saved half the expenditure that it cost him to telegraph 10 years ago. He moved the adoption of the report and accounts and the declaration of the following dividends for the six months to December 31: 6s. per share on the first and second preference shares, and 9d., free of income tax, on the ordinary hares.

The motion was carried.

LONDON ELECTRIC SUPPLY CORPORATION, LIMITED.

Report of the directors and statement of accounts for the year ending December 31, 1893, presented to the shareholders at the seventh ordinary general meeting held at the offices of the Corporation, 3, Adelphi-terrace, W.C., on Wednesday last.

The reports of Dr. Fleming and the engineer, appended hereto, describe the works that have been carried out during the year, and the general condition of the Company's station and plant. During the short time the new transformers have been in use their greater efficiency has sensibly decreased the loss of current. When the whole of them are installed, a considerable advantage will arise from the increase in the proportion of saleable current to current generated. The other important new works described in the engineer's report have proved beneficial, and have materially increased the efficiency of the system of supply. The increase in the number of lights during the year is stated in the engineer's report, and amounts to about 34 per cent. But for the general depression of trade, the rate of increase, which was most marked in the first half of the year, would doubtless have been greater. The result of the year's working shows an improvement on previous years, the revenue account showing a small balance to the good, as against a loss of £3,914. 9s. 7d. last year; and this notwithstanding the reduction of the standard charge to 6d. per unit, and the severe and continuing competition in the best districts of the Company's area of supply. In view of the growing increase in the use of electricity, and of ensuring uninterrupted continuity of supply to consumers, the Board recommend that a new generating unit of 1,250 h.p. be provided as speedily as may be. This, with the necessary apparatus for connecting new customers, will, however, involve a further extension and expenditure of capital. Mr. Francis Ince has retired from the Board. The directors retiring by rotation are Mr. Joseph Pyke and Major C. B. Waller, who, being eligible, offer themselves for re-election. The auditors, Messrs. Kemp, Ford, and Co., who retire in accordance with the articles of association, offer themselves for re-election.

Engineer's Report.—I have the pleasure to report that during the past year the Company's consumers have received a more satisfactory supply of electric energy; the working of the year as a whole, showing a distinct improvement on all previous years, both with regard to the steadiness of the light and the continuity of supply. We commenced the year with a connection of 46,197 lights; at the end of the year the number had increased to 61,924. But for the commercial depression and other disturbing causes in the latter half of year, the increase would probably have been greater. Towards the end of the year a new 300-h.p. dynamo was brought into use. This will prove a great advantage in enabling us to deal with our daylight load without starting the larger machines, and in this way a marked economy will be effected. The 10,000-volt trunk main from Deptford to London, originally fixed to the parapet of the South-Eastern Railway, were removed and laid underground with perfect success during the summer, and without any interference with the continuity of supply. By this important work we are now protected from the accidents from which we suffered so seriously in the past; whilst the annual charges will be considerably decreased, owing to the reduction in the cost of maintenance, and the rental of way-leaves on the railway. The distributing mains have been carried into the parish of Chelsea, and further extensions have been made in the parishes of St. George's, Hanover-square; St. James; St. Martin's; St. George-the-Martyr's; St. Margaret and St. John; St. Saviour's; St. Olave's and Newington; amounting in all to 2¼ miles, bringing the total length of distributing mains laid to 38 miles. All the Company's mains have worked satisfactorily during the year, and the charges for repairs and maintenance have been lessened. A filtering plant, capable of dealing with 100,000 gallons of water per day, has recently been erected at Deptford, by which we are now able to use the river water for the boiler supply, and thus to dispense with a great portion of the supply hitherto derived from the Kent Waterworks Company. This will result in a saving of from £400 to £500 per annum under present conditions. New house transformers, amounting to 2,442 h.p., were purchased last year; of these 1,477 h.p. are now in use on the circuits, leaving in stock 965 h p., which are being put into use as speedily as possible. Owing to the delay of the manufacturers in making delivery, it was not until the last month of the year that this work could be commenced, but from the observations I have taken up to the present time I am able to say that this change will have good economical results. To replace the whole of the old-type transformers now in use, a further 1,045 h.p. of the new type will be required. The generating and distributing plant is in good order, and is working to my entire satisfaction.

P. WALTER D'ALTON, Engineer-in-Chief.

Dr Fleming's Report.—I have read the report of your engineer and agree with it. The replacement of the old form of house transformers by instruments of newer and more economical type has now proceeded to a considerable extent. The result of this exchange has already made itself evident, as we anticipated it would, in a decreased proportion of loss in distribution. There is every reason to believe that when this exchange is completely effected the gain in economy will show itself to the extent indicated in the report of last year. A careful process of testing each transformer for efficiency before it is employed is now adopted. Methods have also been put into operation during the last year for measuring the total daily output from the generating station, which permit the effect of improvements in the distribution plant to be clearly ascertained. A systematic record is thus obtained of the number of units generated as well as sold.

J. A. FLEMING, M.A., D.Sc., F.R.S.

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STATEMENT OF SHARE CAPITAL ON DEC. 31, 1893.

Description of capital.	Authorised by	Number of shares issued.	Nominal amount of shares	Called up per share.	Total paid up.	Issued, not paid up.	Remaining unissued.	Total amount authorised.
£1,000,000 divided into 200,000 ordinary shares of £5 each	Memorandum and articles of association.	111,000 ordinary	£5	£5	£555,000	Nil.	89,000 shares, £445,000	£1,000,000
£250,000 divided into 50,000 preference shares of £5 each	Resolution of general meeting held December 21, 1888.	48,050 preference	5	5	240,250	Nil.	1,950 shares	250,000
					£795,250		£9,750	£1,250,000

STATEMENT OF LOAN CAPITAL ON DEC. 31, 1893.

Description of loan.	Debentures issued. At 5 per cent.	Debentures issued. Total.	Remaining unissued.	Total amount of debenture capital created.	Remaining borrowing powers.
Mortgage debentures...	£67,500	£67,500	£12,500	£80,000	£170,000

Total share capital paid up, £795,250 ; total loan capital borrowed, £67,500 ; total capital received, £862,750.

CAPITAL ACCOUNT FOR YEAR ENDED DEC. 31, 1893.

	Expended to Dec. 31, 1892. £ s. d.	Expended to Dec. 31, 1893. £ s. d.	Total expenditure to Dec. 31, 1893. £ s. d.
Expenditure to December 31, 1892, £820,739. 16s. 7d. Less alterations to offices and stores now written off, £2,691. 17s. 3d.			818,047 19 4
Buildings, freehold land, and general construction account at Deptford—	125,983 5 11	1,193 15 10	127,177 1 9
Plant and machinery at Deptford—	167,595 4 11	11,055 11 5	178,650 16 4
Mains, including cost of laying—	155,040 1 9	11,785 9 2	166,825 10 11
Purchase of the business of Sir Coutts Lindsay and Co., Limited, including plant and machinery at Grosvenor station, goodwill, expenses, etc.—	248,957 13 1	150 0 0	249,107 13 1
Transformers	44,489 0 10	5,387 1 1	49,876 1 11
Meters	6,798 9 9	1,881 4 0	8,679 13 9
Electrical instruments—	13,106 1 10	1,438 13 1	14,544 14 11
Cost of provisional order—	5,050 13 8	14 16 2	5,065 9 10
Tools	1,225 13 7	9 9 10	1,235 3 5
Distributing stations	8,696 6 10	170 15 6	8,867 2 4
Office furniture	794 3 4	Nil.	794 3 4
Cost of redeeming debentures—	30,000 0 0	Nil.	30,000 0 0
Preliminary expenses—	10,311 3 10	Nil.	10,311 3 10
	818,049 19 4	33,086 16 1	851,134 15 5
Balance			11,615 4 7
			£862,750 0 0

Cr.	£ s. d.
Ordinary shares, 111,000 of £5 each (paid)	555,000 0 0
Preference shares, 48,050 of £5 each (paid)	240,250 0 0
Debentures at 5 per cent.	67,500 0 0
	£862,750 0 0

Dr. GENERAL BALANCE-SHEET, DEC. 31, 1893.	£ s. d.
Capital account—amount received	862,750 0 0
Sundry tradesmen and others, due on construction of plant and machinery, fuel, stores, etc., to December 31, 1893	9,749 7 3
Sundry creditors on open accounts	9,054 9 6
	£881,553 16 9

Cr.	£ s. d.
Capital account—Amount expended for works	851,134 15 5
Cash at bankers—Messrs. Coutts and Co., £930. 13s. 9d. ; Messrs. Glyn, Mills, Currie, and Co., £32. 19s. ; The London and County Bank, Deptford, £116. 4s. 4d.	1,079 17 1
Cash in hand	33 16 10
Sundry debtors for current	8,175 6 1
Other debtors	7,866 18 11
Net revenue account	12,633 7 1
Running stores on hand at December 31, 1893	629 15 4
	£881,553 16 9

NET REVENUE ACCOUNT, YEAR ENDED DEC. 31, 1893.

Dr.	£ s. d.
Balance from last account	11,463 6 6
Interest on debentures, etc., accrued and due to date	2,299 1 0
Law charges and stamps on debenture issue	91 9 4
	£13,853 16 10

Cr.	£ s. d.
Balance from revenue account	172 7 0
Forfeited shares, £3,740 ; less alterations to offices and stores written off, £2,691. 17s. 3d.	1,048 2 9
Balance	12,633 7 1
	£13,853 16 10

REVENUE ACCOUNT, YEAR ENDED DEC. 31, 1893.

Dr.	£ s. d.	£ s. d.
A.—To Generation of Electricity.		
Coal or other fuel, including dues, carriage, unloading, storing, and all expenses of placing same on the works	7,234 19 1	
Oil, waste, water, and engine-room stores	1,074 16 5	
Salaries of engineer, superintendents, and officers	405 0 0	
Wages and allowances at generating station	2,686 11 8	
Repairs and maintenance as follows : (1) buildings, £254. 16s. 2d.; (2) engines and boilers, £753. 18s. 6d.; (3) dynamos and exciters, £342. 17s. 5d.; (4) other machinery and tools, £234. 8s. 7d.; (5) transformers and accessories, £109. 2s. 10d.	1,695 3 6	
		13,096 10 8
B.—To Distribution of Electricity		
Salaries of superintendents and officers	235 17 6	
Wages and allowances to linesmen, fitters, etc.	1,261 19 0	
Repairs, maintenance, renewals, and charges of mains of all classes, including materials and laying same ; also wayleaves	1,303 16 4	
Repairs, maintenance, and renewals of transformers, meters, switches, fuses, and other apparatus, on consumers' premises	442 4 3	
Repairs to buildings	266 13 9	
		3,510 11 8
C.—To Rents, Rates, and Taxes.		
Rents payable	1,172 1 9	
Rates and taxes	2,112 5 8	
		3,284 7 5
D.—To Management Expenses.		
Directors' remuneration (not drawn)	1,548 0 0	
Salaries of manager, secretary, engineers, clerks, and messengers	2,407 9 11	
Salaries of canvassers and meter readers	460 13 2	
Stationery and printing	223 15 5	
General establishment charges	392 15 3	
Auditors	52 10 0	
		5,085 3 9
E.—To Law and Parliamentary Charges.		
Law expenses	79 17 5	
Board of Trade audit	87 19 6	
		167 16 11
Balance carried to net revenue account		172 7 0
		£25,316 17 5

Cr.	£ s. d.
Sale of current per meter, less discounts and allowances	22,206 6 1
Sale of current under contracts	866 4 7
Rental of meters, converters, and other apparatus on consumers' premises	1,697 3 3
Transfer fees	10 5 0
Sundry receipts, including students' fees, discounts, etc.	536 18 6
	£25,316 17 5

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The seventh ordinary general meeting was held on Wednesday at the offices, Adelphi-terrace, W.C., under the presidency of Mr. James Staats Forbes. The secretary (Mr. R. Stewart Bain) read the notice convening the meeting.

The **Chairman**, in moving the adoption of the report and accounts, said that they would see that there was a large margin of ordinary capital and a small amount of preference unissued. With regard to the statement of loan capital, he had drawn attention at the previous meeting to the necessity of raising more capital. Lord Wantage, one of the directors, had advanced £50,000 on the mortgage of the Company's undertaking, and the principal money would be due in three years from the contracting of the loan. Since then partly expansion and partly breakdowns and rebuilding had involved the necessity of extending the loan to £80,000. What was to be done in face of that sum? It was practically expended, and the Company would have to devise means of obtaining a small amount of capital to enable them to carry on for the next two years. The loan became repayable in March next year. With respect to the undertaking as a going concern, the accounts for the year showed this, that although they were not as good as they could have hoped, they were a great deal better than in the corresponding year. In 1892 there was a loss of £4,000, but this year a minute profit was shown. The Company had increased the number of lamps from 46,197 in 1892 to 61,924 in December, 1893, or an increase of 34 per cent. Whilst disturbing causes had affected the Company, they must not blind themselves to the fact that the progression during the past year had shown even the most marked improvement in the remedy of the diseases in the various parts of the system. He thought the undertaking would turn upon how far they could establish a character for a continuous and efficient supply. If things had remained normal, the results would have been correspondingly good in respect to receipts, but the receipts showed an increase of only 6 per cent.; therefore they had 30 per cent. more lamps alight to only 6 per cent. additional income. That was easily explained by the facts that the price per unit had been reduced, and that competition among the different companies had led to the diminution in price. It had fallen from 10d. in 1891 to 8d. in 1892, and to 6d. in 1893. The cost per unit had almost become the selling price, and the effect had been the same all round with the other companies. The latter were happy in the sense of being more developed, and because their capacity of development had cost them a vast deal less than the London Company; the former followed in the wake of the known, and did not rush to the unknown. It seemed, however, that the London Company was on the highway to a better state of things. Summing up, it came to this: increase in lamps 34 per cent., increase in receipts 6 per cent., diminution in expenditure 9 per cent., units distributed 30 per cent. increase, and units sold 20 per cent. increase. The effect upon the lamp was various: 6·15 was the price, as against 6·89 in 1892, and 6·92 in 1891. The public were now purchasing current by meter, and were economical in its use. Thus they got hit both ways. The companies might be driven to charge in their own interests what the law allowed them. The cutting of rates, coupled with diminished consumption, would soon find its level. The average consumption per 8-c.p. lamp in 1891 was 20·61 units, in 1892 21 units, in 1893 17·85, arising from the causes referred to. Concerning the apportionment in these accounts of general charges to capital account, it had been considered advisable while the business was progressing to put some of the general charges to capital account. This year they had placed £4,000—other companies had done so—and he believed the Board of Trade would sanction the matter. The result of all their expenditure was this: they had now got machinery in work for the lighting of 90,000 lamps; they had now 65,000 connected. At present they had sufficient reserve to secure them against danger of breakdown, but they would come to the danger point between 70,000 and 80,000 lamps. They ought to spend £12,000 in providing another dynamo of a capacity of 25,000 lamps. They intended to develop existing fields, and not search for new ones. That could not be done without money. As he had remarked, Lord Wantage had found £80,000 on mortgage, and that had practically been exhausted. The directors had thought it desirable to invite the attendance of a number of shareholders before the general meeting. Some gentlemen came, but he was sorry to say they did not make much advance. Those ordinary and preference holders seemed to think it was so hopeless that it was not worth while making any effort. That would be suicide. Surely the £250,000 of preference and £550,000 of ordinary capital was worth making some effort for. It was not as if they had to raise half a million: they only wanted £25,000, which would carry them on for 12 months. Were they going to chuck up the sponge for that sum? If they did so, what would happen? They were in the hands of a gentleman who had the largest interest in the Company, and he did not think that he was likely to resort to extremes. The increase in the number of lamps had proceeded in a satisfactory ratio, and if they went on at that rate they would soon have 90,000 lamps, and the greater portion of the income of the increased number would be absolute profit. A shareholder had formed the idea that the ruin of the Company had been the enormous loss of current in transmission. Well, that loss, according to Dr. Fleming, was only about 5 per cent. The great drawback had been not in the magnetising of the large transformers, but in the small converters of consumers. They had had to take out transformers which were extremely wasteful and put in extremely economical transformers. They had found that the percentage of current sold as compared with that generated was only 45 per cent. They had only introduced a few of the improved transformers, but that process was proceeding, and the result so far had been that in 1893 the proportion of current sold was 49·46 per cent., and at the present it had reached over 50 per cent. They had just arrived at the stage where light was emerging from darkness, and it would be almost a scandal for the people interested in the undertaking to let it drift for want of a little courage. The actual proportion during the quarter ending December 31 of the current put into the mains at Deptford, and received in London, was as follows: lost in the mains, 3·37 per cent.; station transformers, 3·50 per cent.; house converters, 47·70 per cent.; and lamps, 45·43 per cent. To March 31 the figures were: mains, 4 per cent.; station transformers, 3·50 per cent.; house converters, 38·70 per cent.; lamps, 53·80 per cent. He believed that they had during the past week reached 62 per cent. in the latter case. He referred to the reports of Mr. D'Alton and Dr. Fleming. Adverting again to the mortgage, he stated that £30,000 would be required to carry on the undertaking for the next two years. He then moved the adoption of the report and accounts.

Major C. B. Waller, the deputy chairman, seconded the motion.

Mr. Barham adversely criticised the position of the undertaking, and asked whether any effort had been made to meet the other companies so as to prevent rate cutting.

Mr. Mullins considered that it would be useless to attempt to raise money without giving an inducement to do so.

The **Chairman**, in reply to the discussion, said that negotiations were proceeding with the other companies in regard to the cutting of rates.

The motion for the adoption of the report and accounts was put and carried.

Messrs. J. Pyke and Major Waller were re elected directors, and the auditors were reappointed. A vote of thanks to the chairman closed the proceedings.

BUSINESS NOTES.

Bedminster.—It is intended to light Redcliffe Church by electricity.

Worthing.—The town clerk is making enquiries in regard to electric lighting.

Hampstead—The foundation-stone at the central station is to be laid on the 23rd inst.

Hobart Electric Tramway Company.—For the month of April the receipts were £1,174.

Darlaston.—The Local Board are about to consult an electrical engineer on lighting matters.

Western and Brazilian Telegraph Company.—The receipts for the past week were £2,924.

Great Northern Telegraph Company.—For the month of April the receipts were £20,000

West Coast of America Telegraph Company.—The address of this Company is now 50, Old Broad-street, E.C.

Buxton.—The proposal that the Local Board should light Buxton electrically has, it appears, fallen through.

Liverpool Overhead Railway.—The traffic receipts of this railway for the week ending 6th inst. amounted to £874.

Dover.—The electric light company are laying down mains at the back of East Cliff, where their station is being erected.

Belfast.—The Board of Guardians have appointed a committee to consider the question of lighting either by electricity or gas.

Direct Spanish Telegraph Company.—The receipts for the month of April were £1,742 the same as for the corresponding period.

Shoreditch.—The Shoreditch Vestry have decided to make all arrangements for pushing forward the electric lighting of the district.

Pupil Required.—Messrs. Swinburne and Co., Limited, of Teddington, have a vacancy for one premium pupil for electrochemistry.

West Hartlepool.—The Electric Construction Company have approached the Town Council with a view to lighting the town by electricity.

Reuter's Agency.—The prospectus of Reuter's Agency Advertising Company, Limited with a capital of £100,000 is being circulated.

Northumberland.—The County Council have under consideration the question of lighting the asylum electrically. Mr. W. C. Mountain estimates the cost at £5,350.

Removal.—The offices of the Western and Brazilian Telegraph Company, Limited, and the London Platino-Brazilian Telegraph Company, Limited, have been removed to Blomfield House, London-wall, E.C.

Theatre-Lighting at Birmingham.—The firm of Messrs. Vaughan and Brown, of Kirby-street, London, E.C., have been responsible for the lighting of the Empire Palace Theatre at Birmingham.

Harp Arc Lamp Syndicate, Limited—This Company has been registered, with a capital of £5,000 in £1 shares, to enter into an agreement with W. Trubshawe, and to carry on business as electric lamp manufacturers.

Stock Exchange Quotation.—The Stock Exchange Committee have ordered the £150,000 5 per cent. debentures Nos. 1 to 1,500 of the Telegraph Construction and Maintenance Company, Limited, to be quoted in the official list.

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Burton-on-Trent.—The Town Council intend to apply to the Local Government Board for permission to borrow money to complete the electric light installation.

Abergavenny.—The Gas Committee of the Improvement Commissioners are considering a report from the engineer on the subject of lighting the town by electricity.

Shoreditch.—The Shoreditch Vestry have decided that the arrangements for carrying out the electric lighting system by the Vestry shall be pushed forward with all possible despatch.

Bootle.—The Town Council have accepted the tender of Messrs. W. and J. Robinson and Co. for the supply and erection of the electric light installation in the Town Hall and other Corporation buildings for the sum of £3,224.

Wakefield.—The West Riding County Council have accepted the tender of Messrs. Armitage and Hodgson, contractors, Leeds, for the erection of a Council-chamber, etc. The whole of the buildings are to be wired for the electric light.

Californian Electric Power and Mining Development Syndicate, Limited.—This Company has been registered with a capital of 30,000 in £1 shares, to acquire and turn to account electric lighting and power works and mining properties in California and elsewhere.

Runcorn.—The Rural Sanitary Authority have received a letter from the Telegraph Manufacturing Company, of Helsby, stating that Mr. Farrington had called and they had agreed regarding the course and style of the drains to be constructed across Mr. Adamson's field.

Tenders for Electric Tramways.—The Minister of Public Works, Cairo, will receive up to July 1 next tenders for the construction and working of tramways in Cairo and neighbourhood. Either electric or animal power may be used. A deposit of £1,000 (Egyptian) will be required.

Western and Brazilian Telegraph Company.—The Board, after placing £5,000 to the reserve fund and £7,073 to the debenture redemption fund, recommend the payment of 7s. 6d. per share, tax free, being a dividend of £2. 10s. per cent. for the 12 months ended December 31.

City and South London Railway.—The receipts of the Company for the week ended May 6 were £886, against £793 for the same period last year, or an increase of £93. The total receipts for the first half-year of 1894 show an increase of £246 compared with those for the corresponding period of 1893.

St. Pancras.—The St. Pancras Guardians have referred to the Finance Committee the question of lighting the workhouse by electricity. The gas bill at present amounts to about £1,300 a year. The Baths Commissioners have been requested by the Vestry to consider the question of lighting the baths by electricity.

Blackpool.—Messrs. Baxendale, of Manchester, have secured the contract for the laying of the electric lighting plant at the North Pier, the whole of which has to be completed within one month. The pillars for the lights will be placed down the centre of the pier, instead of at the sides, as is the case with the gas lamps.

Tenders for Brighton.—The Town Council invite, by the 16th inst., tenders for the supply of motor alternators, transformers, meters, etc. Specifications can be obtained on application to Mr. Francis J. Tillstone, town clerk, Town Hall, Brighton. Tenders are to be addressed to the town clerk. A fee of £1. 1s. will be charged for the specification.

Tenders for Stores.—The Great Eastern Railway Company invite, by the 17th inst., tenders for the supply of stores and materials, including galvanised iron, tin, lead, etc., cotton waste, telegraph materials, leather, indiarubber, etc. Forms of tender may be had on application to the Secretary's Office, Liverpool-street Terminus, E.C.

Accrington.—A committee of the Town Council have again considered the question of electric lighting, and a deputation, consisting of the Mayor, Alderman Moorby, Councillors Eli Higham and Riley, is to visit Halifax, and inspect the form of destructor in use there for generating steam for electric lighting by the burning of the town's refuse.

General Manager Wanted.—The directors of the Salt Lake and Ogden Gas and Electric Light Company, Limited, invite applications for the post of general manager at their works in Salt Lake City, Utah. Applications are to be sent to Mr. J. A. Kelman, secretary, Salt Lake and Ogden Gas and Electric Light Company, 251, Winchester House, Old Broad-street, E.C.

Bath.—The Town Council have received six tenders for the wiring of the Municipal Buildings, ranging from £497 by the Bath Electric Light Company to £245 by Messrs. Wyndham and Waters, of Croydon. The next lowest was £330, and, said Alderman Murch, not only was the £245 by far the lowest tender, but the firm was unquestionably reliable. The tender was accepted.

York.—At a meeting of the City Council there have been adopted the minutes of the Electric Lighting Committee reducing the tenders for consideration at a special meeting to the following: Brush Electrical Engineering Company, Limited; Electric Construction Company, Limited; Messrs. C. A. Parsons and Co.; and Messrs. Siemens Bros. and Co., Limited.

A Penny in the Slot.—"Sensation," care of Messrs. Deacon's, Leadenhall-street, E.C., advertises that he has patented an electric penny-in-the-slot boot-cleaning machine, which cleans both boots simultaneously, while on the feet, in about one minute. He has a full-sized model in working order, and wants a partner, or a syndicate, with £2,500, to develop sufficiently for forming a company.

Mansfield.—A letter from Mr. Hodson has been read at a meeting of the Water Committee of the Town Council as to the laying of telephonic communication from the new works to the manager's office. It was resolved that the sub-committee confer with Mr. Hodson and the borough surveyor as to the best means of having the telephonic poles erected, and that the work be proceeded with at once.

Issue of Fresh Capital.—The directors of the Hastings and St. Leonards-on-Sea Electric Lighting Company announce the issue of additional £10 shares at par. The list will close to-morrow (Saturday). The prospectus states that dividends of 5 and 7½ per cent. were paid in 1890 and 1891 respectively, and also of 5 per cent. in 1892 and 1893. The additional capital is required for extending the present works.

Thetford.—The question of lighting St. Peter's clock has again been considered by the Town Council. The half-year's bill for gas is £8. An estimate for laying on the electric light has been received. The cost would be for fittings, to include four 8-c.p. lamps, £4. 10s.; light, £6 per year; and for 16-c.p. lamps, £8 per year; the hours to be from dusk to 11.30 p.m. The Council decided to put in the electric light.

South Shields.—The site of the station which the Town Council have decided to erect is at Low Foundry, West Holborn. The Council have adopted the scheme prepared by Mr. Joseph A. Jeckell, the borough electrical engineer, the estimated cost being £22,000. Application is to be made to the Local Government Board to borrow this sum, and a deputation has been appointed to visit several stations recently built.

Brush Electrical Engineering Company.—The offices of the superintending engineer's department have been removed from 112, Belvedere-road, Lambeth, to the undermentioned address. All communications should now be addressed to the superintending engineer, Brush Electrical Engineering Company, Limited, 49, Queen Victoria-street, London, E.C. The telegraphic address will for the present remain "Effulgent, London."

Hastings.—The town clerk has been authorised to give undertakings to persons from whom consent has been or may be obtained to the affixing to their premises of wires, etc., in connection with the fire brigade electric bell communication, to remove the wires, etc., upon receiving such notice as the persons giving the consents may stipulate for, and to pay on demand a nominal annual acknowledgment in respect of the privilege.

Electric Lighting of Trains.—The flooring and sides of the brake-vans in which the accumulators are carried on the electrically-lighted trains of the L.B. and S.C. Railway are being coated with anti-sulphuric enamel, so as to prevent damage by the fumes and spray given off from the batteries. This material is also being employed by the Birmingham Central Tramways to prevent possible damage to the cars from storage batteries.

St. Austell.—With respect to the electric lighting scheme, the Board of Trade have officially reported to the House of Commons that the undertakers are Messrs. Veale and Co., Limited; that the area of supply is the district of the St. Austell Local Board; that the order contains provisions for the supply of electrical energy within the area under certain specified conditions. The order also provides for the revocation of the St. Austell electric license of 1885.

The Nottingham Station.—The contract for the erection of the massive cast-iron chimney cap at this station has been entrusted to Mr. W. J. Furse, of Nottingham, who makes a speciality of that kind of work, and has designed a special hoisting arrangement to ensure the safety of the undertaking. The diameter of the cap is 13ft. 6in., height 8ft., and the weight over nine tons. The shaft, from the designs of the borough engineer, will be 160ft. high, octagon in shape, and built from the inside.

Portsmouth.—The Town Council have decided not to effect any insurance at present on the new station, as all the insurance offices asked 5s. per cent., which, for an insurance of £30,000, meant an annual premium of £75. Several applications have been received by the Town Council for the supply of electricity in Russell-street, and the Electric Lighting Committee have asked for powers to carry the mains with transformers through that thoroughfare at a cost of £550. The necessary permission has been given.

Greenock.—A sub-committee of the Town Council has been appointed to consider a better method of lighting the Town Hall. The *Greenock Herald* suggests that the Council would act more wisely were they to go outside gas lighting altogether, and by using a portion of the waste of water which now runs down certain waterfalls to turn a turbine, not only the hall might, at a very small cost, be illuminated by the electric light, but also the various offices throughout the Municipal Buildings—with the exception, possibly, of the gas offices.

Bathgate.—The electric light has been introduced into Bathgate by Mr. Henry S. Kirsopp, draper, who has had his warehouse and dwelling-house fitted up. The machinery consists of a Tangye gas-engine and an Elwell-Parker compound-wound dynamo. On Friday last the light was turned on by Provost Dougal, in the presence of the Town Commissioners and other public officials. The work has been done by Messrs. Hunter and Jack, 101, St. Vincent-street, Glasgow, and this being the first installation in the West Lothians, it has caused considerable interest in the district.

Chiswick.—The Local Board have received a letter from Mr. Hucklebridge applying for a copy of the agreement for the transfer of the provisional order for Chiswick electric lighting. The matter has been referred to the clerk. The clerk reported at a meeting of the Local Board last week that he had received a

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communication from the Board of Trade with amended regulations as to the supply of electric light in Chiswick, and that he did not regard those alterations as being material. The surveyor stated that the boilers were completed, and that the engines would soon be finished.

Acton.—The Local Board have received a letter from Mr. Medhurst asking for several further alterations to be made in the draft agreement for the lighting of the district by electricity. The Chairman intimated at a meeting of the Board last week that he believed the fact of the matter was that Mr. Medhurst was unable to carry out the proposed contract. There were, he knew, other contractors who would be pleased to take up the work. The letter was referred to the Works Committee, who were empowered to close the negotiations if Mr. Medhurst was not prepared to come to terms without further delay.

Lynton.—At the last meeting of the Local Board, Mr. Benn attended and explained that he was parting with his electric lighting works to a company who were prepared to give a more efficient light by obtaining greater water power. They proposed erecting a storage tank on Summer House-hill capable of giving a two days' extra supply. He asked the Board whether they would be willing to resume the lighting contract with the company for 14 years. It was resolved that on the Board being satisfied that the additional works are satisfactory, and the lighting efficient, the Board would extend the lease as requested.

New Installations in Leeds.—Mr. T. Harding Churton, of Leeds, has secured the contract for the lighting of the Great Synagogue in Belgrave-street, Leeds, by some 77 incandescent lamps of various candle-powers. Among some of the installations recently carried out by Mr. Churton in Leeds may be mentioned the Leeds Law Institute, Philosophical Hall, the Leeds Library, Messrs. Roper and Sons' mill (with accumulators), besides a number of private houses and business premises. The lighting of the medical schools, which are to be opened shortly by the Duke and Duchess of York, is also in Mr. Churton's hands.

St. Luke's.—The County of London and Brush Provincial Electric Lighting Company, Limited, have served notices upon the St. Luke's Vestry of their intention to commence laying mains in the parish. The Parliamentary Committee having considered the matter have recommended that opinion should be taken as to whether the order obtained by the company was effective in view of the fact that its terms had not been observed by the company, and that the Vestry should intimate to the company that it was not prepared to consent to the execution of such works. This has, however, been sent to a special committee, who will thoroughly investigate the whole matter.

Tenders for Southwark.—The Commissioners for Public Baths and Wash-houses for the Parish of St. Saviour, Southwark, invite specifications and tenders for supplying and fixing an engine and dynamo at the baths, Lavington-street, S.E., capable of producing current for 360 16 c.p. lamps, with all necessary exhaust and steam pipes and connections. Tenders are also desired for wiring the above building and providing storage batteries in accordance with the specification prepared by Mr. F. J. Smith, F.R.I.B.A., 17B, Great George-street, Westminster, from whom all information can be obtained, and at whose office the contract can be seen. Tenders are to be delivered by the 16th inst.

Electric Lighting at Manchester.—The Electric Lighting Committee of the Corporation of Manchester have ordered from Messrs. Mather and Platt, Limited, two Edison-Hopkinson dynamos, each of 400 h.p. The machines are to be similar to the two machines already supplied by this firm, having an output of 410 volts and 590 amperes at a speed of 400 revolutions per minute, and are intended to work upon the feeders of the five-wire system. The committee have had so many applications for the electric light that their present plant is fully loaded, and an extension is necessary before next season. These dynamos are to be worked by Galloway engines, similar to those already supplied by this firm.

Bury.—The County Council have adopted the minutes of a meeting of the Electric Lighting Committee, held on May 3, when the borough surveyor submitted drawings, specifications, and estimates for the erection of buildings, engines, boilers, dynamos, and all necessary plant for the supply of electric light to the borough. It was resolved that the plans, specifications (subject to confirmation by Dr. Hopkinson) be approved, and that tenders be obtained for carrying on the works; that the borough engineer dispose of the old material now on the site required for the electric lighting station, and that application be made to the Local Government Board for sanction to borrow £25,000 for electric lighting purposes.

Bradford.—The Town Council on Tuesday decided, on the recommendation of the Gas and Electricity Committee, as stated in our last issue, to issue a circular to residents of the districts of Frizinghall, Manningham, and Heaton, which are not within the area of the gas supply of the Corporation, to ascertain their wishes with regard to supplying such districts with electricity. The electrical engineer in the meantime was authorised to prepare an estimate of cost of suggested works. It was decided to issue a circular to residents in Great Horton-road and Otley-road, and in places in the neighbourhood of those thoroughfares, to ascertain to what extent they would be prepared to take a supply of electricity in the event of the Corporation extending the electric cables to the said districts.

Lighting in Poplar.—The Poplar District Board have discussed the report on electric lighting presented to them by Mr. Preece, which was referred to in a previous issue. Mr. Preece, it will be remembered, strongly recommended the Board to undertake the lighting of the district itself, as after the first year a profit would be made on the undertaking, for which a capital of £30,000 would be sufficient to commence with. He also added that his figures could be relied upon as accurate, and stated that the Board need have no fear of failure in taking the new departure, they having already obtained the necessary parliamentary powers. At a meeting of the Board last week, Mr. Bussey said that he thought it would be a good opportunity to utilise the dust for the purpose of generating the electricity. The Board, however, decided to send Mr. Preece's report to the Works Committee.

Lighting at Hull.—At a meeting last week of the Hull Town Council the most important matter was a discussion on a report presented by the Electric Light Committee, in which it was proposed to reduce the charge for electricity from 7d. per unit to 6½d. Dr. Holden, the chairman of the committee, stated that they spent £1,631 to produce a return of £2,510. and after paying all costs of working, there was a balance of £888, from which £750 went to pay interest, leaving a profit of £138. In the first quarter there were 42 users, in the second 50, in the third 64, and in the fourth 148. They commenced by supplying 3,790 8-c.p. lamps, and ended the financial year with supplying about 9,400. During the 11½ months 74,600 units were used. They expected increased consumption during the coming year, and that they would be able to make a considerable reduction. The report was adopted.

Glasgow.—At a meeting of the Town Council last week, Baillie Alexander asked what progress had been made in regard to the establishment of telephones. Mr. Starke said the matter was before Parliament a few days ago, and Mr. Morley stated that the agreement between the Post Office and the National Telephone Company was still under consideration. That agreement, it was understood, practically gave the monopoly of ground areas in municipalities to the telephone company, the Government taking the trunk wires. Mr. Morley's attention had been drawn to this provision. He was considering the subject, and Mr. Starke hoped that when it was laid before Parliament it would be on different terms from those originally proposed. The refusal to lay the agreement before Parliament till it had been signed had been departed from, and when it was laid before Parliament it would be proposed that a select committee be appointed to consider the whole question.

Sheffield.—The Improvement Committee have passed the following resolution: "That the tender of the Sheffield Electric Light and Power Company, Limited, for the 'wiring' of the Town Hall, for the sum of £750, be accepted, the Corporation to take the current from that company's mains for 12 months from the opening of the complete building, but on condition that the company maintain the installation in good working order during that period, and so leave it at the expiration thereof, and the Corporation to be at liberty, after such period, at any time to discontinue taking the current from the company's mains if the Corporation think fit so to do." The electric lighting company have applied to the Highway Committee for permission to lay cables in Leopold-street, Bow-street, and West-street. It was reported that the footpaths on each side of Bow-street and West-street were to be disturbed for their whole length, and most of the flagging had been laid during the last two or three years, some of it during the last few weeks. The application has been granted.

Gas and Electricity.—The eighteenth annual meeting of the shareholders of the Liverpool Gas Fitting Company, Limited, was held at the Company's offices, Liverpool, on Wednesday, Mr. J. Barkeley Smith, chairman of the Company, presiding. Mr. J. N. Stolterfoht, in moving a vote of thanks to the directors, said that he was glad to see that the Company laid themselves out for supplying fittings for electricity as well as for gas. The newer form of illumination was gaining the upper hand, and they were well advised in keeping abreast of all the possible requirements of the future. The Chairman, in reply, explained that some years ago, when electricity was coming to the front, they altered their articles of association to enable them to supply fittings for the electric light. Had they not done so they would have lost a good deal of business which had lately come to them. The attention of the manager had been specially called to that branch of the business. They were constantly getting orders for it, and that was one reason why they were able to maintain their dividend.

Lighting of Guildford.—The Board of Trade have issued a provisional order under the Electric Lighting Acts, 1882 and 1888, with a view to the same being included in a Confirmation Bill about to be introduced into Parliament, authorising the Holloway Electricity Supply Company to supply electrical energy for public and private purposes in Guildford. The following clause has been ordered by the Board of Trade to be included in the provisional order: "Purchase by the Local Authority.—The option of purchasing the undertaking under the provisions of Section 2 of the Electric Lighting Act of 1888 may be exercised by the local authority within six months after the expiration of 35 years after the commencement of this order, but if the said option is not exercised under the foregoing provision, the said section of the Electric Lighting Act, 1888, shall apply as if this section had not been included in this order." The company will, therefore, have a monopoly for exactly a quarter of a century beyond the period to which the majority of the members of the Corporation originally agreed to consent. Mr. Sidney Sharp is the engineer to the company.

Western and Brazilian Telegraph Company.—The total earnings amount to £80,338. 18s. 3d., as against £86,954. 11s. 2d., showing a decrease of £6,615. 12s. 11d. compared with the half-year to December 31, 1892. The working expenses amount to £35,592. 8s. 10d., as against £37,165. 11s. 5d., a decrease of

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£1,573. 2s. 7d. Including the amount brought forward from June 30, 1893 (£7,679. 4s. 7d.), and the dividend received upon the shares held in the Platino Company, the balance to the credit of the revenue account is £61,659. 9s., from which has been deducted £12,027 for debenture interest, and £7,073 for the debenture redemption fund, leaving £42,559. 9s., of which £5,000 has been placed to the reserve fund. The directors now recommend the payment of a dividend of 7s. 6d. per share, free of income tax, on the ordinary shares, being a dividend of £2. 10s. per cent. for the year, leaving a balance of £1,045. 6s. 6d. to be carried forward. In the case of shares which have been divided into preferred and deferred, the 7s. 6d. per share now recommended will be payable to the preferred shareholders, making up the full dividend of £5 per cent. on the preferred shares for the year 1893.

Lighting of the Agricultural Hall.—The Theatre and Music Halls Committee of the London County Council reported on Tuesday that they had received two plans from Mr. R. Venner showing the formation of engine and electric light rooms in the vaults under King Edward's Hall at the Royal Agricultural Hall. The committee recommended that the plans be approved on the following conditions: (1) that a second iron door be provided at the foot of the staircase leading to such vaults; (2) that the vaults be entirely cut off by a fireproof construction from the surrounding cellars; (3) that an iron ladder with handrails on both sides be provided in order to form a second means of exit into Berners-street from the engine-room, through the present bulkhead; and (4) that the engine and battery rooms in the basements be ventilated to the satisfaction of the engineer of the Council. The committee also reported that they had received four plans from Messrs. Crompton and Co. showing the arrangement of leads, method of suspending cable, and hoisting gear, and the electric lighting plant at these premises. They recommended that the plans be approved on condition that any modifications that may be required by the engineer of the Council be adopted by Messrs. Crompton and Co.

Lighting in Battersea.—In the course of a communication to an evening paper, Mr. G. W. Halliday, of 3, Meath-street, Battersea, says: "About five years ago a proposal was made, and the Works Committee of the Battersea Vestry considered the lighting of that parish with electricity. The Battersea people enjoy in the very centre of the parish the presence of a dust destructor. Some 70 loads of dust are consumed at the destructor per day, and some members of the Vestry have thought it would be well if the consumption of the dust could be used for heating purposes. Mr. Simon wanted it to make the water of the baths tepid, but they heeded him not. I understand, however, that two of the oldest and most practical members of the Vestry have been deputed to visit works and report soon to the Electric Lighting Committee whether or not the consumption of the dust can be utilised for that purpose. Battersea has now 2,000 street lamps, and they cost about £6,000 per annum; and some think that all the energy necessary could be got out of the refuse. Even though all the private lighting had to be supplied by coal as the fuel, it is very doubtful if it would be possible for the Vestry to charge more than 3d. per unit, and the result would be a much better atmosphere than there is now."

Electric Lighting at Bath.—A novelties exhibition has been held in Brock-street. The electrical department, through the enterprise of the electric lighting company and Mr. G. F. Metzger, was fitted up with elaborate completeness. The current was supplied by the company, and Mr. Mactavish, of New Bond-street, who was acting in conjunction with them, exhibited all kinds of novel appliances for the turning of electricity to practical use. The cooking and heating apparatus were kindly lent by Messrs. Crompton and Co., Limited, and alternating motors by the Electrical Company of Oerlikon; whilst the former also lent a search-light. The *Bath Herald* of Friday last says: "The electric lighting company and the Bath Corporation do not work together so amicably as might be wished. The installation of the electric light into the city came certainly as a boon, but the company, as a kind of acknowledgment for their enterprise, have been in receipt of more kicks than ha'pence. The latest outcry in the city is that respecting the late hour at which the lights are switched on, but in justice to those at the works I would explain that the company are acting strictly in accordance with the time-table drawn up by the Lighting Committee, and if there are grievances the Lighting Committee should bear them and not the company. The penalty system adopted has already been referred to in this column. Last quarter the company for 71 failures paid in fines no less than £17. 15s., and yet the gas company got off scot free."

South Staffordshire Tramways.—In the Chancery Division, on Friday, the petition referred to in our last issue for the winding up of the South Staffordshire Tramways Company again came before Mr. Justice Williams. Mr. Bramwell Davis, for the petitioners, read an affidavit to the effect that shareholders representing £70,000 supported the petition, while shareholders to the amount of over £38,000 opposed it. Mr. Buckley, Q.C., opposing the petition for the Company, said the petition had alleged a number of matters for the purpose of establishing a case of fraud. These charges had failed, and no case was made out. He, therefore, asked that the petition should be dismissed with costs. Mr. Warmington, Q.C., for the debenture-holders, said their only chance of getting their money back was to keep the company as a going concern. It was proposed to extend the area of tram lines, and, instead of steam traction, to use electric power and cable. Mr. Justice Williams expressed the opinion that it was not desirable the business should continue to be managed by the receiver for the debenture-holders under circumstances which gave the shareholders no voice at all. Mr. Bramwell Davis said the shareholders wanted to remove Mr. Wain from the chairmanship of the company, and to have an efficient voice in the management. It was ultimately arranged that the petition should be adjourned in order that a meeting of the shareholders should be held in London. The shareholders were to say whether they were in favour of a winding-up order or not.

Accepted Tenders.—The following tenders were received for alterations to sub-station in Pavilion-road, for the Chelsea Electricity Supply Company, Limited:

T. D. Leng, Deptford	£474
W. Stevens and Co., Chelsea	438
J. Douglas, Chelsea	391

The tender of the latter has been accepted. For alterations to sub-station in Manor-street, for the Chelsea Company, the following tendered:

T. D. Leng	£638	0	0
W. Stevens and Co.	613	0	0
J. Douglas	515	10	0

The tender of Messrs. Baxendale and Co., of Manchester, has been accepted for the construction and maintenance for a period of five years of a telephone between the asylum and Glanywern Hall, a distance of about three miles, for the Visitors of North Wales Counties Lunatic Asylum. The following tenders were received by the Brighton Town Council for the supply and erection of Willans engines, continuous-current dynamos, pipe-work, spare armatures, etc.:

Crompton and Co., London	£5,550	0	0
Siemens Bros. and Co., Westminster	5,940	0	0
India Rubber, etc., Company, Silvertown	6.046	0	0
Johnson and Phillips, London	6 095	10	0
Electric Construction Company, Wolverhampton	6,257	0	0
Easton, Anderson, and Goolden, Limited, London	6,503	0	0

The tender of Messrs. Crompton and Co. has been accepted.

Whitehaven.—At a meeting of the Whitehaven Town and Harbour Trust, Mr. J. G. Dees, the chairman, in connection with the estimates for the year, mentioned that the cost of public lighting this year had been considerably more than was estimated, and he had explained in part the reason of that—that there was one quarter's gas account, £256. 6s. 1d. The actual expenditure for lighting during the 12 months had been as follows: For the 12 months all expenses against the electric lighting station, repairs of lamps, etc., including the bills paid for gas during the period of the year the town was lighted by gas, and also the harbour, £949. 6s. 3d.; amount paid for sinking fund and interest, £130. 15s. 9d.; or a total of £1,080. 2s. The revenue collected was £207. 13s. 3d; leaving the net cost of public lighting for the year ending March 25, €872. 8s. 9d., or £11. 17s. 2d. less than the preceding year, when the town was lighted by gas, the cost of gas having been £884. 5s. 11d., in a year when the cost was considerably less than before owing to strictest economy exercised in lighting. So he thought they might congratulate themselves on the first year's working of the electric lighting. With regard to the next year's electric lighting, it would come to something rather more. The estimated expenditure of the electric lighting station was £930. That is the amount of expenditure at the electric lighting station chargeable to electric light: there is a portion of it charged, of course, to sewerage, which is something considerably less than the cost of the sewerage station used to be. The estimated revenue from electric lighting is £1,063 15s., which is made up of the amount payable by the harbour under contract £220, and the sale of current estimated at £843. He thought this estimate was a very fair one. Last year, the amount of current sold to consumers during seven months was 26,000 units. The surveyor's estimate of the requirements of the 12 months was 45,000 units; and he (the chairman) thought that was very moderate, inasmuch as during those seven months it was only towards the end of the seven months that many of their big customers were obtained, and very few of their customers ran the whole of the seven months.

PROVISIONAL PATENTS, 1894.

APRIL 30.

8500. **Electrical connector for making insulated joints under water or clay between cable or other insulated wires.** Henry R. Vereker, Summerville, Westport, County Mayo.

8512. **Improvements in and connected with insulators for overhead electrical conductors.** Arthur Wiglesworth, 10, St. George's-crescent, Liverpool.

8525. **A method of overcoming induction on telephone and transmitting lines.** Addison Goodyear Waterhouse, 33, Old Broad-street, London.

8534. **Improvements in electrically-propelled vehicles.** Walter Charles Bersey, 53, Chancery-lane, London.

8539. **Improved telephone and exchange system.** Emile Andreoli, 18, Somerleyton-road, Brixton, London. (Pierre Emile Raverot and George Albert Hess, France.)

8548. **Improvements in the construction of spring reels for roses for ceilings or wall connections and other electrical fittings.** Killingworth William Hedges, 8, Quality-court, Chancery-lane, London.

8556. **An improved electrically-operated door-chain or the like.** Eduard Stoessel, 6, Lord-street, Liverpool.

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8552. **Improved commutator brush.** Rudolf Kersberg, 23, Southampton-buildings, Chancery-lane, London. (Complete specification.)

MAY 1.

8566. **Improvements in alternating and multiphase current dynamos.** Thomas Parker, Manor House, Tettenhall, Wolverhampton.

8567. **Improvements in brushes and brush-holders for electric generators and motors.** William Harding Scott, Gothic Works, King-street, Norwich.

8585. **Improvements in electric conductors for underground conduits.** Daniel Ellis Conner, 45, Southampton-buildings, Chancery-lane, London. (Complete specification.)

8587. **Improvements in and relating to electric railways.** Henry Harris Lake, 45, Southampton-buildings, Chancery-lane, London. (William Burridge Purvis and Meylert Melville Armstrong, United States.) (Complete specification.)

8599. **Improvements in electric arc lamps or lighting apparatus.** Joseph Barclay McKeown, 11, Southampton-buildings, Chancery-lane, London. (Complete specification.)

8607. **Improvements in or appertaining to electrical exchanges.** William Phillips Thompson, 6, Lord-street, Liverpool. (Alexander E. Keith, United States.) (Complete specification.)

8613. **Improvements in or appertaining to automatic electrical exchanges.** William Phillips Thompson, 6, Lord-street, Liverpool. (The Strowger Automatic Telephone Exchange, United States.) (Complete specification.)

8617. **An electric alarm bag.** Thomas Nickalls White, 45, Fitzroy-street, Fitzroy-square, London.

8634. **Improvements in the means for controlling electric lamp circuits from a distance.** John Corry Fell, 1, Queen Victoria-street, London. (R. H. Postlethwaite, New Zealand.)

8638. **Improvements in alternating-current, simple or polyphase, dynamo-electric machines.** Sydney Pitt, 24, Southampton-buildings, Chancery-lane, London. (André, Blondel, and Sautter, Harlé et Cie., France.) (Complete specification.)

MAY 2.

8654. **Improvements in apparatus used as brackets or chandeliers for electric light.** Robert Neville Grenville and Stephen Harding Terry, 17, Victoria-street, London.

8730. **Improvements in and connected with supports for electrical batteries used on vehicles and the like.** Thomas Froggatt, 1, Queen Victoria-street, London.

8731. **Improvements in electric batteries.** Thomas Froggatt, 1, Queen Victoria-street, London.

8733. **Improved electrical fire and burglar alarm.** Henry Dawson, 45, Hatton-garden, London.

MAY 3.

8761. **Improvements in and connected with electric fire alarms.** Andrew Archibald and George Tarry, 154, St. Vincent-street, Glasgow.

8773. **An automatic electric fire alarm time call.** Frederick Hungate Dennis, 20, High-street, Chelmsford.

8794. **New or improved electrical appliances enabling trains in motion to have constant and direct telegraphic communication with the stations or other trains on the same line.** Pierre Emile Marie Bastion, 77, Colmore-row, Birmingham.

8795. **An improved holder or support for the receivers of telephones.** Andrew Connel, 8, Quality-court, Chancery-lane, London.

8807. **New or improved means for protecting magnetic needles from local attraction.** John Sacheverell Gisborne, 19, Southampton-buildings, Chancery-lane, London.

8808. **Improvements in electric batteries.** Robert M'Lauchlan M'Donald and Alexander M'Donald, 70, Wellington-street, Glasgow.

8812. **Electrical jacquard apparatus for looms.** Siemens Bros. and Co., Limited, 28, Southampton-buildings, Chancery-lane, London. (Messrs. Siemens and Halske, Germany.)

8813. **Improvements in electric conductors.** Siemens Bros. and Co., Limited, and Wilhelm Dieselhorst, 28, Southampton-buildings, Chancery-lane, London.

8815. **Improvements in electrolytic cells.** Ludwig Mond and Robert Ludwig Mond, 323, High Holborn, London.

8823. **Improvements relating to the transmission of signals through telegraph lines and cables.** Joseph Arthur Lovel Dearlove, 124, Chancery-lane, London.

8825. **Improved means for conducting electricity through tablecloths, carpets, and the like, to electric lamps and other electrical devices.** The Electrical Installation Company, Limited, and Edmund Lyons O'Brien, 55, Chancery-lane, London.

8838. **Improvements in fuses or cut-outs for electric lines.** Jacob Pillischer, 226, High Holborn, London.

MAY 4.

8895. **Improvements in or connected with secondary or electric storage batteries.** Frank King, 47, Lincoln's-inn-fields, London.

8896. **Electrical apparatus for preventing collisions and other accidents on railways.** Alfred Joseph, 53, Chancery-lane, London.

8917. **Improvements in or in connection with apparatus for the electro-deposition of metals.** Hans Alexander, 34, Southampton-buildings, Chancery-lane, London. (Complete specification.)

MAY 5.

8924. **Self-contained electrical generating apparatus and driving mechanism.** Charles Langstone, Benjamin Young, and James Alfred Ewins, 8, Coleshill-street, Birmingham.

8972. **Improvements in or relating to secondary batteries.** Frederick Griffin, 46, Lincoln's-inn-fields, London.

8976. **Improvements in submarine telegraph cables.** William Sharpey Seaton, 124, Chancery-lane, London.

SPECIFICATIONS PUBLISHED.

1885.

4671.* **Voltaic batteries.** Fitz-Gerald. (Second edition.)

1888.

17795. **Electrical arc lamps.** Brockie. (Second edition.)

1893.

7711. **Secondary batteries.** Schoop.

10042. **Secondary batteries.** King.

10134. **Dynamo-electric machines.** Sayers and others.

10142. **Electric generators, motors, etc.** Fritsche.

11122. **Secondary batteries.** Peyrusson.

11384. **Electric generators.** Raworth.

11728. **Electric switches.** Moy.

11759. **Electric bells.** Turnbull.

12011. **Electric alarm for steam-boilers.** Brown.

12141. **Electrical switches.** Tyer.

15715. **Distribution of electricity.** W. G. and C. W. G. Little.

20381. **Electric light fittings.** Claremont.

22863. **Dynamo-electric machines, etc.** Lake. (Thomson-Houston International Electric Company.)

1894.

3111. **Electric signalling devices.** Haddon. (Williams.)

3749. **Galvanic batteries.** Boult. (Cudell and others.)

3986. **Electric motors.** Thompson. (Ries Electric Speciality Company.)

5118. **Electro-locomotion on railways.** Heys. (Heilmann.)

COMPANIES' STOCK AND SHARE LIST.

Name.	Paid.	Price Wednesday.
Birmingham Electric Supply Company	5	5⅛-5⅜
Bournemouth Electric Company	—	—
Brighton and Hove Company Original	100	210-215
Brush Company, Ordinary	2	2⅞-3
—— Nom. Cum., 6 per cent. Pref.	2	2⅞-2⅝
—— 4½ Debenture Stock	100	108-111
Charing Cross and Strand	5	4½-5
Chatham and Rochester	—	—
Chelsea Electricity Company	—	—
City of London, Ordinary	10	12-13
—— 6 per cent. Cumulative Pref.	10	13½-14
—— 5 per cent. Debenture Stock	75	83-85
City and South London Railway, Consolidated Ordinary	100	28-30
—— Debenture Stock	100	109-111
—— 5 per cent. Pref. Shares	10	11-11½
Crompton and Co., 7 per cent. Cum. Pref. Shares	5	3¼-3⅜
—— 5 per cent. First Mortgage Debentures—1-400 of £100 and A, 1-200 of £50	100	95-100
Elmore's French Company	2	⅛-¼
Electric Construction, Limited	2	⅛-¼
—— 7 per cent. Cumulative Pref.	2	1⅛-1⅛
Elmore's Copper Depositing	2	⅛-¼
Electricity Supply Company for Spain	5	—
Elmore's Wire Company	2	1-1⅛
Fowler-Waring Cables	5	⅛-1⅛
W. T. Henley's Telegraph Works, Ordinary	10	6-7
House-to-House Company	5	⅛-1
India Rubber and Gutta Percha Works	10	23-24
—— 4½ per cent. Debentures	100	102-104
International Okonite, Ordinary	10	1-2
Kensington and Knightsbridge	5	4⅜-5⅛
Liverpool Electric Supply, Ordinary	5	6⅛-6⅝
—— Pref.	4½	5⅝-6⅛
Liverpool Overhead Railway	10	7⅛-7½
—— 4 per cent. Mortgage Debentures of £100	100	107-100
London Electric	5	⅛-1⅛
Metropolitan Electric Supply	10	7⅛-8
—— 5 per cent. Reg. Debentures, 1-10,000 in Bonds of £10, £20, and £40	—	108-111
National Telephone, Ordinary	5	4⅜-5
—— 6 per cent. Cum. First Pref.	10	15-16
—— 6 per cent. Cum. Second Pref.	10	14⅜-15⅛
—— 5 per cent. Nom. Cum. Third Pref.	5	5⅜ 5⅝
—— 4½ per cent. Deb. Stock	—	114-116
Notting Hill Company	10	4⅛-5⅛
Oriental and Electric Company, £1 shares	11	⅛-¼
Southampton Electric Company	—	—
St. James's and Pall Mall, Ordinary	5	6⅛-7⅛
—— 7 per cent. Pref.	5	8-8⅛
Swan United	3⅛	2-2⅛
Telegraph Construction and Maintenance	12	39-41
—— 5 per cent. Bonds	100	104-107
Westminster Electric Supply, Ordinary	5	5⅜-6⅛
Yorkshire House-to-House	4⅛	4⅛-4⅜

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NOTES.

Rugby.—A proposal is on foot to establish a telephone exchange.

Castrop.—The electric light is shortly to be installed in this town.

Heilmann Locomotive.—It appears that this locomotive is now making daily trips.

Tetschen-Bodenbach.—The Municipality intend to erect a central electric light station.

Ayr.—The Ayr Corporation have resolved to light the town by electricity, at a cost of £15,000.

Frankfort-on-the-Maine.—The electric light is to be installed in the Rothschild Free Library.

Saint-Nazaire.—M. Ch. Milde has applied for permission to establish an electric supply station.

Hamburg.—Large extensions are being made in the main conductors of the municipal electricity works.

Braila.—Tenders will be opened this month for the lighting by gas and electricity of this Roumanian town.

Rochester.—The question of the overhead wires being removed is under the consideration of the Town Council.

Arts and Crafts Society.—Lord Mayo has issued the prospectus of a scheme for forming an Arts and Crafts Society for Ireland.

West Ham.—The West Ham Town Council have decided to allow the electric lighting scheme to go into abeyance for the present.

Nachod.—A local manufacturer proposes to erect a central electricity station for the lighting of the streets and private houses and shops.

Obituary.—The death has just occurred of Mr. Arthur Edward Robinson, head chemist at the Electric Construction Company's Works, Bushbury.

Bordeaux Tramways.—A new company proposes to convert the suburban tramway lines into electric lines, similarly to the Bordeaux-Vigeau route.

A Bull.—"I mean to say," remarked Mr. Hammond at the Institution meeting last week, "that if everybody had a copy of the paper nobody would have to read it."

The Clermont-Ferrand Tramway. — The last year's operations of the company operating this line and also a tramway in Marseilles, allow of a dividend of 4·8 per cent.

Durham.—Mr. H. F. Tulloch, Local Government Board inspector, has held an enquiry into the application of the Corporation to borrow £20,000 for electric lighting purposes.

The Institution.—The paper by Mr. R. E. Crompton on the "Cost of Electrical Energy" will be further discussed at a meeting of the Institution on Thursday next, the 24th inst.

Colwyn Bay.—The Local Board have addressed a memorial to the Postmaster-General, requesting that the existing telephones at Colwyn Bay may be connected with the trunk line.

Traction at Dublin.—The Kingstown Commissioners are desirous of learning from the Dublin Southern District Tramways Company when it is probable that the new electric lines will be laid.

Congratulations.—Sir David Salomons, who presided over the two last meetings of the Institution, is to be congratulated on the business-like manner in which he conducted the proceedings.

London Chamber of Commerce.—The twelfth annual general meeting of the members of the Chamber will be held at the offices, Botolph House, Eastcheap, on Monday next, at 2.30 p.m.

Ruhla.—The first electric lighting plant in Ruhla has been installed at the metal-works of Herr Ferdinand Erk. Several other installations in the neighbourhood will now be supplied with current from the same plant.

What About Electricity?—A discussion has taken place in the Harwich Town Council on the respective merits of gas and oil lighting of the streets. The members do not seem to have heard of the electric light.

The Breslau Electric Tramway.—The first annual report of the company working the electric tramway states that a dividend of 4·7 per cent. will be paid after having provided for depreciation, interest on capital, and reserve.

Liebertwolkwitz.—The Municipality of Liebertwolkwitz, near Leipzig, have decided to adopt the electric light, and preparations will shortly be commenced. The lighting of the market place and the chief streets will be undertaken first.

Schonlinde.—In response to circulars asking who would take electric current if a central station were erected, promises have been obtained which show that there would be a regular demand for current for 1,100 incandescent lamps.

American Institute of Electrical Engineers.—The tenth anniversary of this institute is being held this week in Philadelphia. Among the papers down for reading is one by Dr. Louis Bell on "Some Facts about Polyphase Motors," whilst one by Mr. Wurts will deal with "Lightning Arresters."

Zwickau.—A short time ago a successful experimental run was made on the electric tramway, which has been carried out by Messrs. Schuckert and Co., of Nuremburg. Overhead conductors are employed, which are carried on ornamental posts.

Hard Lines Mixed.—"It seems hard lines," said Mr. Burnett before the Institution last week, in reference to the purchase of fuel by central-station engineers, "to sell light and heat in B.T.U. and have to buy their own materials mixed."

New York.—The overhead trolley system of electric traction has now made its appearance in New York—a line on this method having just been completed on One-hundred and-thirty-fifth street. The regular service of the cars is about to commence.

Wolverhampton.—On Monday next, at 12.30 p.m., the foundation stone of the municipal electricity works in Commercial-road, Wolverhampton, will be laid, and invitations to be present have been issued by the Mayor (Alderman C. T. Mander).

Gas-Engines.—The Saint-Quentin Gas Company is laying down plant for the supply of the electric light in certain parts of the town. Direct-current dynamos have been adopted in conjunction with gas-engines, and the distribution will be on the three-wire system.

Steinau-on-the-Oder.—The Babolz Engineering Works are to be lighted electrically, and it is proposed to make the installation large enough to light the whole town. The Municipality have agreed to take a supply for 342 incandescent lamps and nine arc lamps.

Haardt.—Good progress is being made in the erection of the central station near Haardt and Neustadt, which is being erected on their own account by Messrs. Schuckert

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and Co., Nuremburg, for the lighting of Haardt, Gimmeldingen, Mussbach, and neighbouring districts.

Romanshorn.—The Municipality have decided to erect a central electric light station in connection with the pumping plant of the waterworks for lighting the railway station and the village. Romanshorn will be the first village in Thurgau, Switzerland, to adopt the electric light.

How to get a Day Load.—The directors of the Westminster Electric Supply Corporation, Limited, have decided to reduce, after Midsummer, the price of electrical energy for motive power, cooking, and heating purposes to 4d. per unit, where the supply is taken through a separate meter.

Cannstadt.—At the new technical college an electric installation has been carried out by the Esslingen Works in the art teaching rooms. The lights are so arranged as to be readily adjustable, and in the model-room the lights are so fixed that the shadows fall the same as they would from sunlight in the open air.

Telephony in Germany.—The telephone network from Berlin, *via* Posen, Gnesen, Bromberg, Danzig, and Elbing to Königsberg has not been available at Königsberg owing to the local authorities having raised objections to the installation of the conductors in the streets. The difficulty has, however, now been removed.

Bristol Electric Time Check.—A catalogue referring to the Bristol electric time check has reached us from Messrs. King, Mendham, and Co., of Bristol, who are the sole licensees. The advantages of this apparatus for checking time in factories and other large establishments where workpeople are employed are now well known.

Monmouth. — The Bill introduced by the Board of Trade to confirm the provisional order empowering the Monmouth Corporation to produce electricity and to lay mains for the supply of current has passed the Examiner upon Standing Orders in the House of Commons, and has been ordered to be reported for second reading.

Gollnitz.—A central electric light station is being erected at Göllnitz (a Hungarian mining town) which will supply 800 incandescent lamps. A separate dynamo of 30 h.p. is to be put up to furnish current to motors for industrial purposes. The work is being carried out by Messrs. Egger and Co., of Vienna and Budapest.

Posen.—The number of electric light installations in this province is rapidly increasing. Sugar refineries at Tuczno, Zduny, Kruschwitz, etc., have been lately thus lighted, and so has the provincial lunatic asylum at Dziekanka, near Gnesen. The chief stations of the Posen-Thorn-Bromberg Railway are also to be lighted electrically.

New French Company.—The Société Générale Internationale d'Eclairage par le Gaz et l'Electricité has been constituted in Paris, with temporary offices at 17, Rue Saint Marc, for the supply of gas and electricity. It is proposed to establish agencies in French and foreign towns, notably at Brussels, Bucharest, Vienna, and Budapest.

Personal.—Mr. E. R. Dolby, C.E., of 8, Princes-street, Westminster, S.W., has been appointed consulting engineer to Messrs. C. H. Glover and Co., Hatcham Saw Mills, for electric power transmission plant and electric crane; to the London Missionary Society; and to a colliery in Derbyshire for lighting, transmission of power, and pumping by electricity.

The Use of Gas-Engines for Electric Light.—Mr. F. H. Mason, the United States Consul-General in Germany, states that since the Frankfort Electrical Exhibition of 1891 the use of gas motors has very largely increased through the cheapening of gas, and the rapid extension of electric lighting and other applications of electricity.

Wreschen.—The electric lighting installation of the local sugar refinery is nearing completion. The residents of the town have now formed a committee for the erection of a central station, which is to be carried out by the General Electricity Company, of Breslau. It will have a capacity for 500 incandescent lamps and 20 arc lamps (for street-lighting).

The Upper Spree.—The Electric Lighting Company of the Upper Spree have informed the authorities of the surrounding districts that their plans have been approved of, and that they are about to commence the erection of their station. The Town Council of Rummelsburg have already decided to enter into negotiations with the company for the lighting of the town.

The Hamburg Tramways.—In a previous issue reference was made to the opening of the electric tramway in this town, and we now learn that the Hamburg Tramways Company has applied to the Senate for permission to use electric traction on all its lines, and that the permission has been granted. The contemplated conversion of the system is to be completed within three years.

Ship-Lighting.—The twin-screw steamer "Duke of York," which has just been completed by Messrs. William Denny and Bros., of Dumbarton, has just made a trial trip in the Firth of Clyde. The electric lighting plant consists of a Crompton dynamo driven by a Browett-Lindley engine. The dynamo is capable of supplying current for 250 incandescent lamps and also for the search-light.

Folkestone.—A special meeting of the Corporation has been held to consider petitions for and against the introduction by the Town Council of the electric light. The resolution passed at the meeting of April 6, approving of a scheme for the installation of the electric light at a cost of £35,000 was revoked, this motion being carried by nine votes against six after two hours' stormy discussion.

Union of German Electrical Engineers.—The council of the Verband der Elektrotechniker Deutschlands, whose address is at Schiffbauerdamm 22, Berlin, N.W., have issued the preliminary programme of the second annual meeting of the union to be held, as stated in previous issues, at Leipzig in June. The proceedings, which will commence by a reception of members on the evening of June 7, will continue for several days.

The Halle Tramways.—It appears that the working of the electric tramway in Halle has adversely affected the horse lines. The company operating the latter proposed some time ago to acquire the electric tramway, but the Municipality placed in the way obstacles which have until now prevented the transfer of the line from the General Electricity Company. It is not known whether negotiations will be resumed.

Havre.—The Havre Chamber of Commerce has offered to advance the State a sum of 92,000f., or, say, about £3,680, for the establishment of a third telephonic connection with Paris, on the condition that the line is reserved exclusively for communications between the two towns until the reimbursement of the sum advanced. In case this stipulation be not agreed to, the Chamber reduces its offer to one half of the sum.

Budapest.—The works of the Budapest General Electricity Company, which compete with those of Messrs. Ganz and Co., in Budapest, are making good headway. They were erected nine months ago, and were projected for 12,000 lamps, while now 16,760 lamps are connected, and

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application has been made for 36,860 more. The works were erected by Messrs. Schuckert and Co. The local authorities have approved of the scheme for an underground electric railway.

Central Stations in the United States.—Mr. E. A. Armstrong, in his presidential address before the National Electric Light Association, said that, according to the most trustworthy information available, there were now in the United States upwards of 2,300 electricity supply undertakings, representing an invested capital of at least £40,000,000, and that it was estimated that an equal amount was invested in the manufacture of electrical machinery and supplies.

Walker.—A Mr. Walker, Congressman for Massachusetts, has got a nice vocabulary for electrical enterprises. The owners of electric tramways on the trolley system he describes as being "a cruel, heartless, remorseless combination of interests that has no regard for human life or the comfort of citizens," while leading electric manufacturing firms are depicted as "these great dominant unprincipled combines," who have gone in for the conduit system of traction "with the malignity of the infernal regions."

Electricity in Mining.—The Royal mines at Aranyidka, near Kaschau, Hungary, are receiving an interesting electrical installation. At the primary station there is to be a dynamo of about 30 h.p., giving current at 500 volts. This dynamo is driven by a turbine. The secondary station is about a mile distant, and here an electromotor drives the hauling machinery. In order to avoid irregularities in the running of the turbine, it will be provided with an electrical regulator, made by Messrs. Egger and Co., of Vienna and Budapest.

Lifting a Cable.—The cable steamship "Menia," Captain Trolt, belonging to the Anglo-American Telegraph Company, London, has started from Queenstown for the North Atlantic. One of the Anglo-American cables has been found defective in mid-Atlantic, the defective portion lying at a depth of 2,500 fathoms. On lifting the cable it will have to be overhauled, and all the defective parts cut out and replaced by new cables. The "Menia" has aboard 500 miles of new cable, 200 miles of which, or perhaps more, will have, it is calculated, to be used.

To Whom is the Credit Due?—Mr. Nelson W. Perry, an American electrician, in discussing the question of the measurement of electric current, mentions that of the greatest desiderata in many electrical measuring instruments is a material whose electrical resistance shall not vary with the temperature. For a long time German silver was more used than any other known alloy, but Mr. Perry says that it remained for an American, Mr. Edward Weston, to invent an alloy having a zero temperature coefficient. Mr. Perry adds that "the credit for this has been usurped by foreigners, but the honour is due to America."

Aix-la-Chapelle.—The supply of current from central electric lighting stations for tramway purposes is of much importance to those running the stations. In Hamburg the consumption on the tramways already amounts to one-fourth of the total output. It has now been decided to adopt electric traction on the Aix-la-Chapelle tramway, and to take current from the electric lighting station, which was carried out by Messrs. Schuckert and Co. The overhead trolley system is to be employed. The length of the line which is to be thus operated at first is about 14½ miles, which will subsequently be increased to 18 miles. Of 35 cars, 19 will be supplied with 15-h.p. motors, so that they can haul trailers. The rest will have 10-h.p. motors.

Electric Supply at Vevey.—Some interesting particulars and figures are to be obtained from last year's report of the operations carried on by the electrical company of Vevey, Montreux, who supply energy, it will be remembered, for working a tramway and a number of lamps, both arc and incandescent. The total number of passengers carried by the former during the year was 1,309,240, being an average of some 3,586 per day, and the total receipts amounted to £9,013, an average of, say, £25 a day, or about 1½d. per passenger. Penny fares account for more than half of the total receipts. At the end of the year, the company was supplying current for 9,032 incandescent lamps and 35 arc lights, and the receipts from this source amounted to £7,513. Although based on a water-power station, the company's business increased so much that, owing to the dry season, an expenditure on coal fuel was made necessary of no less than 14 times as much as in the previous year. The financial results, however, were still favourable enough to allow of a 5 per cent. dividend, besides putting aside £1,000 to the reserve fund and a similar sum to replace the cost of special repairs during the year.

The Royal Society.—"Some time ago," says the *Chronicle*, "we mentioned a rumour that the 15 candidates selected by the Royal Society's council would be largely of the professorial and South Kensington order. This forecast was pronounced by a distinguished official as unfounded, since the selection had not then been *officially* made. The list is, however, now out, and, it is interesting to find, quite confirms the general talk in scientific circles, for the majority belong to the class who have long had almost absolute control of the society, while several names are quite unknown to us. We may now mention that some weeks ago three lists of probably successful candidates were drawn up, two by Fellows well acquainted with the personal leanings of the council, and one by an outsider, who judged the list of applicants solely by their merits. The result was that in one list appears 12 of the selected names, in another eight certain and two problematical, and in the third only six of the men now decided to have F.R.S. affixed to their names were considered worthy of that distinction. The society publishes the names of the selected candidates; why does it not give those of the unsuccessful ones? Then the public could judge for itself."

Douglas Electric Tramway.—A trial run in connection with the Douglas and Laxey Coast Electric Tramway took place on Thursday of last week. The tramway is being constructed by a company, and, when completed, will extend from Douglas to Laxey, seven miles distant. The route taken is for the most part by way of the precipitous sea cliffs that lie between Douglas and Laxey, and in connection with the tramway a very fine marine drive has been laid out. The first section of the tramway, extending from Douglas to the Glen of Groudle, is completed, and the cars ran the distance of four miles along the marine drive with remarkable smoothness. There was not the slightest friction observable, and the trial was a success. A large number of gentlemen, either connected with the company or with the engineers, made the journey, and expressed themselves as being well pleased with the working of the tramway. The current for working the line is generated at a large station in Douglas, and is conveyed to the cars by overhead wires. The tramway has been constructed and the electrical installation put in by Messrs. Mather and Platt, of Manchester, under the personal superintendence of Dr. Hopkinson. The completed section was opened for public traffic on Saturday, and it is expected that the whole line will be finished by July 1.

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Lecture.—At the twelfth meeting of the Royal Scottish Society of Arts held in Edinburgh on Monday, Mr. Mathew Buchan read a paper on "The Practical Application of Electricity to Domestic and other Purposes." He referred to the introduction of electric current into the town, and said that the Corporation did not undertake to do more than the Gas Commissioners did now, and the installation of electric wires would in time become part and portion of the plumbers' trade; but his advice was that they should not be trusted with the work in the meantime. Wires, switches, cut-outs, and fittings must be installed by a private electric contractor, and the work must be done to stand the test of the Corporation's electrical engineer. Light for light the cost would be about 40 per cent. more than gas, but the saving in other directions by its use would materially reduce the price. Mr. Buchan displayed and described various styles of fittings, and explained the difference between the arc and incandescent lamp. Electricity as a motive power was next dealt with, and its advantages, such as absence of smell and noiselessness, were pointed out. The cost was about 50 per cent. greater than gas power. In conclusion, he showed how electricity was manipulated in order to produce heat for cooking and other domestic purposes.

Electric Installation by the Great Northern Railway.—In a recent issue we gave a description of the electric light installation carried out by the Great Eastern Company at Liverpool street. The Great Northern Railway Company are following suit by the construction of a central electrical station of their own, which is situated at Holloway between the Great Northern main line and the North London line. Current will be supplied from this for the arc lighting of the passenger station and goods yards at King's Cross. There are already 100 arcs in use in these goods yards. The Finsbury Park and Holloway stations are also to be lighted by arc lamps, and the company's offices and hotel will be lighted by incandescent lamps. The supply station is divided into two main sections—the boiler-house and the engine-house. In the former, which is 80ft. long by 43ft. wide, are five Lancashire boilers, 28ft. long by 8ft. in diameter. A Green's economiser is installed, and Bennis's mechanical stokers are fitted to the boilers. To avoid a breakdown, everything in the boiler-house is in duplicate. When everything is complete, the engine-house will contain 12 Fowler engines. Five of these, of 100 h.p. each, will work two dynamos apiece for the supply of arc lamps. Two engines of 100 h.p. have already been erected for the alternators. The main cables have been laid in a trench beneath the floor of the engine-house. From the works the cables run through the siding area to the Great Northern main line.

Royal Meteorological Society.—The monthly meeting of this society was held on Wednesday evening, Mr. R. Inwards, F.R.A.S., president, in the chair. Mr. W. Ellis, F.R.S., read a paper "On the Relative Frequency of Different Velocities of Wind," in which he discussed the anemometer records of the Greenwich Observatory for the five years 1888-1892, with the view of ascertaining the number of hours during which the wind blew, with each of the different hourly velocities experienced during the period. The results of this discussion show that the wind blew for the greatest number of hours with the hourly velocities of 10 and 11 miles. Mr. W. Marriott, F.R.Met.Soc., gave an account of a series of observations on the "Audibility of Big Ben at West Norwood," which he had carried on for a period of five years. The clock tower at Westminster is 5½ miles distant from the point of observation in a north-by-west direction. The large bell "Big Ben" was designed by Lord Grimthorpe, and was cast in 1858; its weight is about 14 tons. It is 9ft. 5½in. in diameter and 9⅜in. in thickness, its tone being E. The observations were 976 in number, and were made at the hours of 9 a.m. and 9 p.m. The bell could be heard more frequently in the evening than in the morning, and on Sundays it was more frequently audible than on weekdays. The direction of the wind most favourable for hearing "Big Ben" was between west and north. The observations were also discussed in relation to temperature, moisture, cloud, and barometric pressure. A paper by Mr. A. W. Moore, on "Earth Temperatures at Cronkbourne, Isle of Man, 1880-1889," was also read.

Electric Traction in Switzerland.—At a special meeting recently held in Lausanne of the committee formed to promote the more rapid development of electric tramway lines in the town, some additional particulars besides those already published were given by Prof. Palaz concerning the erection and equipment of a tramway from the Place Saint-François to La Pontaise. The total length of line first proposed is a little more than a mile, with maximum grades of 11·5 per cent., or, say, 1 in 9. The vertical height or difference of levels through which the cars are lifted is therefore about 250ft. The line is of metre gauge, and electric traction upon the overhead wire system is stated to be preferable to the use of a rack line, though no good reason appears to exist why the two should not be combined as on the line at Barmen. The cars are designed to carry 36 passengers each, with sitting accommodation for 24, and the minimum number of journeys per day will be 24 in winter and 36 in summer. For the full journey—occupying 20 minutes—a fare of 3d. is to be charged, with intermediate 1d. and 2d. stages. Each car is to be fitted with two electromotors, having a total maximum output of 50 h.p. Water power in this case would be too expensive, and probably oil or gas engines will supply the necessary motive power at the generating station. The cost of erection and equipment is estimated for the complete station at £10,000 to £12,000. Comparing results from similar enterprises, an average of half a million passengers would, it is estimated, give total receipts per annum equal to about £2,600, with an expenditure of £1,800, leaving a net profit of £800.

The Leeds Tramways.—We understand, according to a Leeds paper, that, in answer to the advertisement of the Leeds Corporation for offers to work the Leeds tramways on a lease, only three communications have been received. One of these is from the Thomson-Houston Company, who are working the Roundhay Park cars on the overhead system. The company intimate that the conditions to be imposed by the Corporation are such that they are not prepared to say what they will pay per mile for the right to work the undertaking, though they are willing to extend, for the Corporation or any other proprietors, their Roundhay Park electric system throughout the city. Mr. Graff Baker, who formerly managed the Roundhay Park section for the Thomson-Houston Company, submits two offers. In the first tender he undertakes, on behalf of a syndicate or company, to work the lines by electricity, the wires being overhead or underground, at £220 per mile for 21 years on the local authority's terms. As an alternative proposition, the company Mr. Baker represents say that if the Corporation do not require them to take over the existing plant, and will undertake to accept their (the company's) plant 21 years hence, they will pay £500 a mile for the right of working. The third offer comes from Mr. Graff Baker personally, and it is said to be a repetition of the tender of the company he acts for with these alterations—that he is willing to

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give £300 instead of £220 a mile on the Corporation's stipulations, and £520 instead of £500 if he has not to be saddled with the existing plant, and may hope to sell his stock-in-trade to the Corporation 21 years hence. It is reported that the Tramways Committee are disappointed with this result of their endeavours to get the undertaking off their hands.

Arc and Incandescent Lamps.—In a recent issue of a French journal, M. A. Bainville compares the cost of lighting by means of incandescent lamps and arc lamps under different conditions of supply. He distinguishes between private generating stations where the cost of power is low, and central stations where it is generally much higher, taking the unit at 0·5d. and 3d. in the first case, and 6d. and 1s. in the second case. In making an estimate of the cost of arc lighting, he assumes the expense for carbon to vary from 0·11d. to 0·45d. per hour, according to the current employed, the extreme limits being three amperes and 20 amperes. The annual cost for renewals and repairs to arc lamps he takes at 30 per cent. on the cost of the lamp, this being estimated at £6. The labour required for cleaning and trimming the lamps he assumes at one hour for each lamp per day. A table is given showing the cost per spherical candle-hour calculated on the above basis. As regards lighting by incandescent lamps, the author distinguishes between four different cases when lamps are employed requiring 2, 2½, 3, and 4 watts per candle, having a life of 150, 300, 600, and 1,000 hours respectively. The resultant costs per spherical candle are given on the supposition that the light is required on an average for six hours per day. In comparing the results he finds that where the power can be obtained at the low rate of ½d. per unit, the three-watt incandescent lamp is, under all circumstances, more economical than the more efficient incandescent lamp or arc lamp. Where the power can be obtained at 3d. per unit, incandescent lamps consuming from 2 to 2½ watts per candle are the most economical. With power at 6d. per unit, the arc becomes more economical than the incandescent lamp when the light required from each exceeds 300 candles, and at 1s. per unit the limit is 150 candles, the most economical type of incandescent lamp to be used being that which requires two watts per candle. The general result of the author's investigation is that under nearly all circumstances the incandescent lamp is preferable to the arc lamp.

Engineering Laboratory at Cambridge.—On Tuesday last Lord Kelvin opened the new engineering laboratory at Cambridge University. There was no laboratory in the university until the present movement originated, three years ago, in the appointment of a committee, when Prof. J. A. Ewing was appointed to the chair of mechanism and applied mechanics, and a committee was formed to collect subscriptions for the building of the laboratory. The amount thus far realised is £5,000, and the list is still open, as one of the wings of the building remains to be completed, and much has yet to be done in the way of equipment. The subscriptions were supplemented by a grant of £1,000 from the funds of the university, which enabled the south wing to be built. In addition to actual money subscriptions, a large number of gifts of apparatus and machinery have been made by various engineers, including Lord Kelvin, Sir Joseph Whitworth and Co., Mr. C. A Parsons, Mr. A. A. Common, Mr. Alexander Siemens, and others. In many cases, too, manufacturers have supplied plant on exceptionally favourable terms. The laboratory is designed in three parts—a central block, with south wing and large north wing, which latter has still to be built. On the ground floor of the front block are two large rooms for electrical testing, as well as offices. Behind this block is the old hall of the Perse School, which is converted into a mechanical laboratory; beneath this is the heat laboratory; and lying off of this is a large laboratory for steam-engines and dynamos. The south wing includes classrooms and research laboratories. An adjoining site is reserved, to which, when funds allow, it is intended to remove the university workshops, which were established many years ago by Prof. J. Stuart. Instruction in the workshops is still part of the scheme of teaching in its now greatly developed form. The two together now form a very complete course of study of the scientific side of engineering as a preparation for professional life. The laboratory work has been going on in the old building for some time, but under great difficulties, on account of the inadequacy of the accommodation.

Transmission of Power from Niagara.—An elaborate estimate of the distance to which Niagara water power can be economically transmitted by electricity is given by Messrs. E. J. Houston and A. E. Kennelly in the *Electrical Engineer* of New York of May 2. After going into details, the authors conclude as follows: "The foregoing results indicate that on the basis of prices and voltages assumed and detailed, the power of Niagara Falls can be transmitted to a radius of 200 miles cheaper than it can be produced at any point within that range by steam-engines of the most economical type with coal at 3dol. per ton. That Niagara power can maintain at Albany a large day and night output cheaper than steam-engines at Albany can develop it, but that for power taken at Albany for 10 hours per diem the best steam-engines have somewhat the advantage over Niagara unless exceptionally favourable conditions of load could be secured for Niagara power. These conclusions are, of course, entirely dependent upon the reliability of the prices, voltages, and estimates as detailed above. The prices, however, appear to be conservative, and are probably in excess of the latest market values. This would also appear from the statement recently published that the Cataract Construction Company has contracted for the privilege of right of way for conducting lines along the Erie Canal banks, by supplying power for barges at the annual rate of 20dol. per horse-power (26·81dol. per kilowatt), whereas the above figures make the average cost of production 20·792dol. per horse-power (27·872dol. per kilowatt) on the basis of an average output of 0·6 full load; so it would appear that the Niagara Power Company are in the possession of better prices. Moreover, if the voltage delivery on the long lines, here taken at 35,350 at the receiving end, can ever be safely increased, a marked reduction in the cost of delivery would naturally result. The broad conclusion to which an enquiry of this nature inevitably leads, is that while under ordinary conditions the commercial limit of electrical transmission of power from water powers of less than 500 kilowatts can hardly exceed 50 miles, the radius at which it will be profitable, with good fortune and management, to electrically transmit a water power aggregating 50,000 kilowatts, or more, is, perhaps, to-day, 200 miles, and that it might be commercially advantageous for such a large water power to undersell large steam powers at twice this distance with no profit, in order to reduce the general expense upon delivery nearer home. The reason for this difference in the transmission radius between small and large water powers, lies obviously in the fact that electrical and hydraulic machines can be built and purchased much more economically in large sizes than in small, so that the cost of producing and of maintaining one kilowatt is very much less for large than for small water powers."

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ELECTRICAL EXHIBITION AT DERBY.

An electrical exhibition, to which we referred in a previous issue, was opened by the Mayor (Mr. J. P. Doherty) on Monday in the Lecture Hall. The object of the exhibition, which has been promoted by the Electric Lighting Committee of the Town Council, is to popularise the applications of electricity in the district, and for another two weeks the inhabitants will have an opportunity of seeing for themselves the advantages of electricity for lighting, heating, and power purposes. The engineer and manager is Mr. J. E. Stuart, A.I.E.E. The municipal electricity works were started on October 10, 1893, and were described in the *Electrical Engineer* at the time. The demand for the supply of current has increased continuously ever since the opening of the station, when there was current going out to only two consumers who were then connected to the mains, these two having between them about 180 8-c.p. lamps. There are at present over 65 consumers connected to the mains, and these have a total equal to over 3,000 lamps. Twenty to thirty consumers, with a number of lamps equal to another 5,000 8-c.p. lamps, are waiting to be connected to the mains, or are having their premises wired. This would represent the entire output of the station as it now stands, and it is for this reason, and in view of further pending enquiries and applications for the supply of current, that a new 250-i.h.p. engine and dynamo are now being added. The amount received for current from the opening day—October 10, 1893—to March 31 last, with an average taken over the whole period of only about 1,500 8-c.p. lights connected, was £474. 7s. 10d. The public street arc lighting has also been very successful. Lamps are being continually got into place, and shortly there will be in all nearly 80 lamps burning at one time. It is estimated that to the same date—*i.e.*, March 31 last—and when charged at the rate common for such lamps as those in Derby—of £25 per lamp per annum, each lamp burning for, say, 3,000 hours—as much as £505. 15s. has been earned for public lighting. The demand for current to be used for power and for purposes other than lighting has not, up to the present, been as extensive as it will be in the near future. This is probably owing to the fact that customers do not yet fully appreciate how useful an agent electricity is for producing motive power. One of the main objects of the exhibition is to impress this fact upon consumers.

The Electrical Company, Limited, of Charing Cross-road, London, W.C., occupy the first stand with exhibits comprising a search-light, Luna arc lamps for direct and alternate current, German Edison incandescent lamps of any voltage and candle-power for every socket in the market, lampholders, main, branch, and combination switches, safety fuses, installation material, cables, wires, flexible cord, electroliers, testing instruments, voltmeters and ampere-meters, reading telescopes with scales, Stabilit insulating material, storage batteries, and electric heating and cooking apparatus.

Messrs. Walter T. Glover and Co., of Salford, Manchester, are ably represented at the second stand by samples of cables for electric lighting, telephones, and torpedoes, armoured and lead-covered cables, concentric, and other varieties.

Messrs. Pyke, Harris, and Co., Limited, 34-36, New Tothill-street, Westminster, London, S.W., show at the next stand high-tension apparatus, illustrating various degrees of illumination produced in vacuum tubes under similar inductive influence, the gaseous vacuum being different in each case. There are also to be found a high-tension transformer, a small "Combination" transformer, and an alternating-current dynamo designed to work on the inductor principle.

Messrs. C. A. Parsons and Co., of Heaton Works, Newcastle-upon-Tyne, have on view a 1½-unit steam-turbine dynamo, and a six-unit Heaton dynamo having an output of 92 amperes at an E.M.F. of 65 volts. There are also exhibited an Admiralty type projector, a 10-h.p. kilowatt transformer, and a 3-h.p. kilowatt transformer.

Messrs. Crompton and Co., of London, show their well-known electric heating and cooking apparatus. These are on view in Room No. 5; and demonstrations, with cookery lectures, are given daily at 3 and 7 p.m. by Mrs. Mary Seaton. Lectures on the practical application of electricity for domestic purposes (particularly with regard to cooking) will be given at intervals during the exhibition by Mr. H. J. Dowsing, M.I.E.E.

Messrs. W. T. Henley's Telegraph Works Company, Limited, of 27, Martin's-lane, London, E.C., exhibit samples of various insulated cables for electric lighting, submarine telegraphy, telephones, torpedoes, etc., fancy coloured electric light cords, jointing materials, lamps, etc.

Messrs. F. and C. Osler, of London and Birmingham, display a variety of electrical fittings intended to illustrate two methods of lighting a drawing-room. This is accomplished, first, by means of a group of lights in a richly cut-glass dish (with a silvered reflector inside) fixed near the ceiling, supplemented by movable standing lights on the piano, on occasional tables, or elsewhere. The second method shown is by means of single pendants suspended from the ceiling at suitable points.

The General Electric Company, Limited, of 71, Queen Victoria-street, E.C., show a variety of electric heating and cooking apparatus. Among these may be mentioned coffee machines, hatter's iron, cigar lighters, glue-pot, a ⅛-h.p. motor and one of ½ h.p., fan and guard, curling-iron heater, kettles, frying-pans, saucepans, steam cooker, ovens, griller, etc.

The Edison and Swan United Electric Light Company, Limited, of 100, Victoria-street, Westminster, S.W., exhibit samples of various descriptions of incandescent lamps of all candle-powers, and electric light fittings of high class—for instance, ship-light fittings, casings, cut-outs, switches, switchboards, holders, motors, and cables—whilst shades of several designs, and for all purposes, are also to be found.

Messrs. John Davis and Son, of All Saints' Works, Derby, and 118, Newgate-street, London, make a display of large arc lamps and miniature arc lamps suitable for lighting interiors of churches, shops, etc., electroliers and brackets, electric motors, advertising signs and devices, cooking and heating apparatus, engraving machines, ventilating fans, carved and enriched casing for leads, switches and switchboards, incandescent lamps and shades in great variety, and telephones.

Messrs. Siemens Brothers and Co., Limited, exhibit a selection of cable samples, leading-wire samples, rubber samples, ebonite samples, and electric light fittings for ship work. There are also on view Siemens's incandescent lamps, Hellesen's dry cells, Obach's dry cells, and other forms of cells for telegraphic purposes, and a selection of electric light carbons, switches, and cut-outs.

Mr. Henry Baker, of 30, London-road, Derby, exhibits an assortment of electroliers, electric pendants, brackets, fittings, etc., a variety of electric lamps, lampholders, switches, cut-outs, fuses, cables, wire, lamp-shades, and other accessories for house and shop lighting, and electric signalling apparatus.

On Wednesday evening Sir Frederick Bramwell, Bart., delivered an address on the applications of electricity.

ANOTHER ELECTRIC LOCOMOTIVE.

The accompanying illustrations—reproduced from the *Railroad Gazette* of New York—show the general form and construction of an electric locomotive now being built by the Paris, Lyons, and Mediterranean Railroad, after the designs of Mr. H. Bonneau, chief engineer of the road, and Mr. E. Desroziers, for trial in fast passenger service.

The locomotive, as will be seen from the engravings, has four driving wheels, a four-wheel leading truck and a two-wheel trailing truck, the drivers and trailing truck being so mounted as to form a rigid wheel base of 15ft. 7in. supporting the frame by half elliptic springs. The springs of the trailing truck are placed above the boxes, while the driver springs are underhung and equalised. The leading truck is mounted somewhat after the fashion of Webb's well-known radial axle, with a considerable range of lateral motion, being held normally in a central position by means

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of springs. In order to gain a maximum amount of space for the driving mechanism, the frames, which are of plate construction, are placed outside the driving wheels.

The motors are slow-speed six-pole machines of the Desroziers pattern, a separate motor being mounted on each axle. The armature shafts are hollow, their internal diameter being sufficient to give considerable clearance to the driving axles which they surround. It will be observed from the cross-section that the commutator of this motor is close to the armature and surrounded by the pole-pieces. It is claimed that this construction permits the use of a more powerful motor than would otherwise be possible in the limited space between the drivers. The brushes are easily reached through the openings between the pole-pieces. The field magnets are supported by heavy lugs on the motor frames bearing on vertical rods, the heads of which are cup-shaped as to permit a slight lateral motion of the motors. These rods are supported on U-shaped girders fastened at the upper ends to the frames, but are provided with buffers of Belleville washers in order that shocks may not be transmitted vertically from the frames to the motor. The motor is thus supported clear of the axle and transmits motion to the drivers through the system of drag links shown in Figs. 2 and 3. A double-plate ring surrounds the axle and is connected to it by means of two short rods or links placed diametrically opposite to one another. Two similar rods perpendicular to the first connect this ring with the driver. In order to give this connection the greatest possible freedom of motion, ball bearings are provided at the ends of each rod.

Beneath the motors and secured to the U-shaped girders is a casing of sheet iron and wood of sufficient length to protect both motors from dirt and moisture, and carried up to the frame at the sides and ends. The upper part of each motor is left uncovered, with the exception of the armature, which has a light iron casing. A light cab covers the whole locomotive, thereby protecting the motors and apparatus.

In order to avoid, if possible, the necessity of erecting conductors along the road, especially for branch lines, the railway company proposes at first to experiment with storage batteries, arrangements being made for carrying them over the leading truck of the locomotive. The necessary apparatus for controlling the supply of current, and for the application of brakes, is placed also at the front of the locomotive, where the engineer will have an unobstructed view of the track ahead.

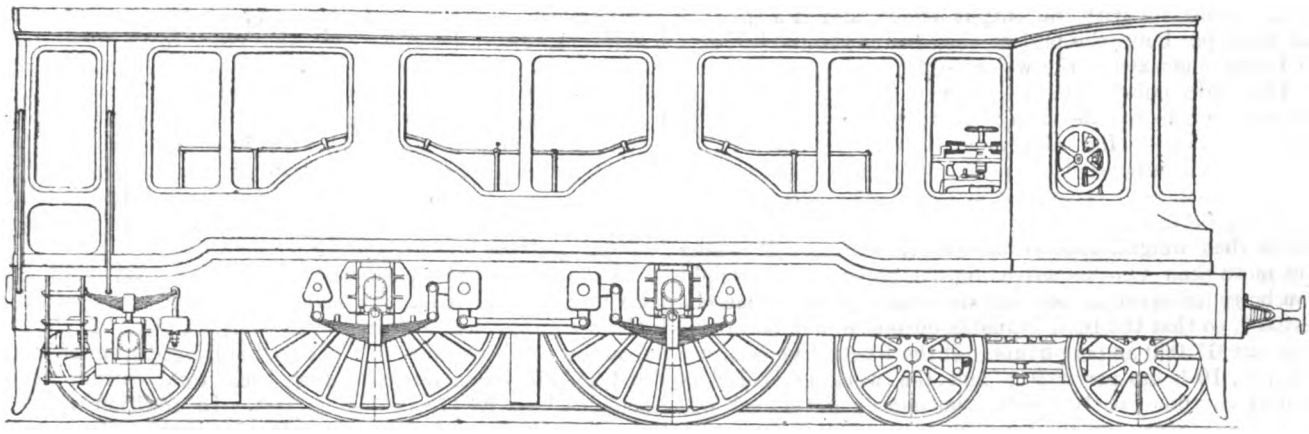

FIG. 1.

The general dimensions and weights of this locomotive are given as follows:

Driving wheel base	8ft. 6⅜in.
Rigid wheel base	15ft. 7in.
Length over buffers	37ft. 1⅛in.
Diameter of drivers	7ft. 8½in.
Diameter of trailing truck wheels	4ft. 7⅛in.
Diameter of leading truck wheels	4ft. 1½in.
Weight on drivers	63,933lb.
Weight on leading truck	28,660lb.
Weight on trailing truck	44,092lb.
Weight of frame and accessories	70,548lb.
Weight of motors	55,115lb.
Weight of apparatus	2,204lb.
Weight of storage batteries	8,818lb.
Total weight	136,685lb.

It is calculated by the designers that the locomotive above illustrated will have a maximum power of 1,200 h.p. The first locomotive is to have a power of only about 300 h.p.

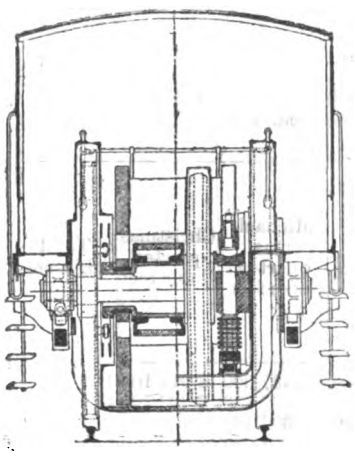

FIG. 2.

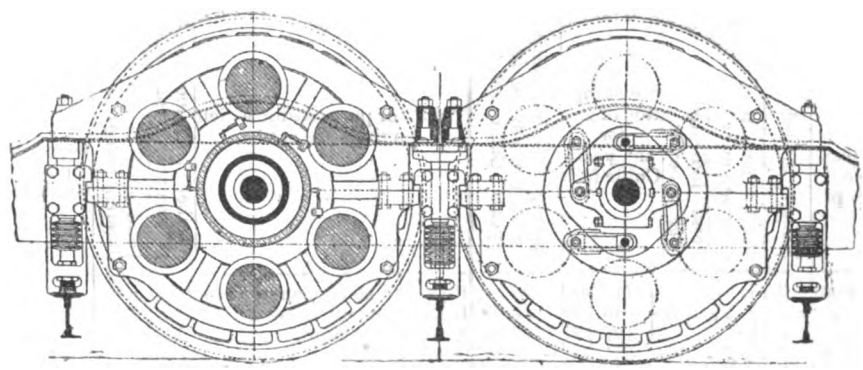

FIG. 3.

The details thus given of the new locomotive are not, perhaps, very clear; certainly they are hardly sufficient to enable an accurate idea to be obtained of the full powers and qualities of the device. Even the few particulars herein set forth, however, merit considerable criticism, more especially as electric traction is not yet in a position to be trifled with by ill-planned schemes of an over-ambitious nature.

No details are offered as to the speeds obtained with this locomotive, either normal or maximum; but as it is intended for fast passenger service, probably we shall be safe in assuming an average velocity of 45 miles per hour. This implies a speed of rotation in the driving wheels of about 160 revolutions per minute—quite a normal speed for motors of this type, considering the large output claimed for them. When, however, the weight is taken into account, we can only say that the design of these motors

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must be very excellent indeed when an output of 1,200 h.p. is obtained from them.

As a general rule, large electric motors under the most favourable circumstances, require a weight of, say, at least 1cwt. per horse-power developed, so that the result in this case is most favourable when a weight of not quite 25 tons in the motors gives an output of 1,200 h.p., or more than twice the usual proportion! It would seem almost more than probable that some mistake has been made in regard to this point, for with the output named, and at a speed of 45 miles per hour, the pull on the level is about 11,000lb., or barely one-sixth of the weight on the drivers.

The main point, however, deserving of criticism is the proposal made by the designers to use accumulators or storage batteries for supplying electric energy to the motors. To suppose that rather less than four tons of accumulators will propel at high speeds a locomotive weighing 68 tons, and a train of perhaps twice or three times that weight, appears absolutely absurd. Probably not more than two ampere-hours per pound gross weight can be relied upon as the output from a good commercial battery, so that the total available output would be in this case, say, 17,000 ampere-hours. If the locomotive is in use for, say, 10 hours per charge, and the working E.M.F. of motors be taken at 100 volts, the energy developed will not exceed 250 h.p., an amount which will obviously be insufficient to propel such a train at high speeds.

It will be found in practice, moreover, that unless these battery locomotives be confined to one locality of limited area—be used, for instance, to carry out shunting operations—the cost of erecting stations at different points to recharge the batteries would probably exceed any outlay required for line conductors. The trolley wire, or its kindred types, cannot be beaten for cheapness, either for capital outlay or working expenses.

GAS-ENGINES.

In the course of his inaugural address last week before the Incorporated Institution of Gas Engineers, Mr. Alfred Colson (the new president) made the following remarks concerning the use of gas-engines.

Estimates have from time to time been made of the quantity of gas used by cooking-stoves, but I know of none with regard to that taken by the total number of engines in use in any large town. A favourable opportunity has also been afforded me for arriving at this, inasmuch as we let on hire wet meters only, which has necessitated the purchase by the consumers of the dry meters required in connection with the engines. The result is that, with scarcely an exception, we have in our books a separate registration of the gas used by every engine in the town. Table A, given herewith, for the year 1893, gives the various sizes of engines in use, the number of each size, together with the total horse-power, also the average and total consumption of gas per engine, and, in addition, the number of engines employed in different trades, and the quarterly and year's consumption of gas by each trade. For the engines fixed during the year, the full 12 months' consumption has been calculated from the actual quantity of gas consumed by each for the time being.

The table includes particulars referring to 377 engines, varying in size from one man power to 20 h.p. nominal, which engines are working most satisfactorily. It shows that the year's consumption per engine ranged from 23,050 to 1,358,800 cubic feet, and that their total consumption amounted to 82,418,100 cubic feet. In addition to the engines enumerated in the table, there are 36 others, equalling 253 h.p. nominal, which have been fixed during the present year, including five of 20 h.p. each. The consumption of gas by these will amount to at least 10,000,000 cubic feet per annum; making a total annual consumption of 92,000,000 cubic feet, the greater proportion of which will be used during daylight hours. This quantity amounts to 8·52 per cent. of last year's consumption for all purposes. I find that the engines at present are working at scarcely half their limit; for supposing them to work for 54 hours per week, as they nearly all do, and allowing 20 cubic feet of gas per indicated horse-power per hour, the consumption of gas would be over 200,000,000 cubic feet per annum. Here, then, is a source of increasing consumption without considering any prospective increase in the number of engines. It is quite evident from these figures that no pains should be spared on our part to secure the success of every gas-engine put down by seeing that mains and services are sufficiently

TABLE A.—GAS-ENGINES IN LEICESTER, 1893.

Gas-engines.				Total consumption of gas for the year. Cubic feet	Average consumption of gas per engine for the year. Cubic feet.	Trades or purposes for which engines are used.	Number of engines used by different trades or purposes.	Total nominal h.p. used by different trades or purposes.	Consumption of gas by various trades by engines for the year 1893.				
Size. Nom. h.p.	Number at work.	Total nominal horse-power.	Total indicated horse-power.						Lady Day quarter. Cubic feet.	Mid-summer quarter. Cubic feet.	Michaelmas quarter. Cubic feet.	Christmas quarter. Cubic feet	Total cubic feet.
1 man	2	2½	5	117,500	58,750	Boot and shoe manufacture	122	644¾	8,714,500	8,798,300	8,487,300	8,916,100	34,916,200
5 ,,	2			46,100	23,050	Hosiery manufacture	56	207¼	3,440,200	3,456,800	3,662,100	3,602,700	14,161,800
6 ,,	1			127,400	127,400	Electric lighting	10	73½	819,600	705,500	692,100	892,900	3,110,100
¼ h.p.	8	2	40	651,900	81,487	Coffee grinding	2	5½	124,800	89,200	83,000	127,200	424,200
½ ,,	38	19	95	2,102,400	55,326	Sand-paper manufacture ...	1	½	13,000	13,500	14,400	14,400	55,300
¾ ,,	2	1½	6	196,100	98,050	Cigar manufacture	1	¾	23,600	7,000	15,300	42,600	88,500
1 ,,	35	35	115	2,707,600	77,360	Needle-making..... ..	1	¼	10,600	8,200	8,100	10,000	36,900
1½ ,,	4	6	15	316,400	79,100	Engineers and machinists...	45	126½	1,773,300	1,662,200	1,632,200	1,844,100	6,911,800
2 ,,	57	114	256	6,399,100	112,264	Printers.....	33	115½	1,271,500	1,197,200	1,210,600	1,310,900	4,990,200
2½ ,,	11	27½	60	1,575,500	143,227	Corn merchants	16	71½	525,200	337,300	437,600	610,100	1,910,200
3 ,,	22	66	143	2,835,200	128,872	Mineral water manufacture	13	26½	199,200	294,700	318,000	209,100	1,021,000
3½ ,,	26	91	211	3,316,000	127,538	Builders & timber merchts.	21	127	1,084,000	1,057,200	1,003,800	1,089,100	4,234,100
4 ,,	28	112	274	5,347,900	190,996	Bakers and confectioners...	11	26	286,900	246,400	254,100	364,800	1,152,200
4½ ,,	2	9	21	253,900	126,950	Brewers and maltsters	10	22¼	232,100	148,300	106,400	255,600	742,400
5 ,,	8	40	91	1,463,800	182,975	Elastic web & braid manu.	8	62½	1,159,900	1,134,200	1,117,700	1,041,000	4,452,800
6 ,,	53	318	689	14,029,200	264,701	Wool spinning	5	12½	73,100	61,600	66,200	65,500	266,400
7 ,,	21	147	327	7,184,100	342,100	Fancy-box manufacture ...	3	14	178,900	178,500	175,700	170,600	703,700
8 ,,	16	128	280	5,818,500	363,656	Cabinet and picture frames	6	17½	227,400	159,900	154,500	217,500	759,300
9 ,,	12	108	234	6,129,100	510,758	Rope manufacture	3	14	141,800	123,800	115,500	139,900	521,000
10 ,,	5	50	107	2,306,700	461,340	Wholesale clothiers	2	15	213,700	207,000	229,900	181,800	832,400
12 ,,	15	180	393	11,179,500	745,300	Dairies	2	½	40,200	17,600	15,100	38,400	111,300
14 ,,	4	56	132	2,780,800	695,200	Pumping and ventilating ...	4	16	292,200	178,400	186,900	195,700	853,200
16 ,,	2	32	82	1,457,000	728,500	Manufacturing chemists ...	2	4½	42,700	42,700	39,700	38,000	163,100
20 ,,	3	60	147	4,076,400	1,358,800		—	—	—	—	—	—	—
	377	1604¼	3723	82,418,100			377	1604¼	20,888,400	20,125,500	20,026,200	21,378,000	82,418,100

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large, and the pressure ample for ensuring at all times an adequate supply of gas. I attribute in a measure the success of the gas-engine in Leicester, where its use is rapidly extending, to the careful attention that is paid to these requirements. As to the day pressure under which gas is supplied, my practice does not accord with the advice given in the well-known "golden rule" relating thereto. Until 10 years ago the rule referred to was carefully observed, with the object of keeping the "unaccounted-for" at a minimum; but so much trouble and annoyance were experienced with regard to the supply to both engines and cooking-stoves during the daytime, that the pressure was gradually increased from 10-10ths to 19-10ths, and with the best results. It may surprise some to learn that this increase of pressure has led to no increase in the "unaccounted-for," the average of which for the last 10 years, under the higher pressure, is 2·67 per cent.; while for the previous six years, under the lower pressure, it was 3·16 per cent. It is needless to say that the distributing plant is in first-class condition.

THE ELECTRIC MOTOR.*

BY PROF. F. B. CROCKER, COLUMBIA COLLEGE.

A single lecture cannot possibly do justice to a subject of the magnitude and importance of the electric motor. There are, however, certain salient and interesting points which, when touched, give the keynotes of the entire subject. Some of these are contained in the history of the electric motor, and others in the action of the machine itself.

In taking up the historical consideration, we have the amber of the ancients as the first electric generator, corresponding to the dynamo, and its attraction of feathers and other light bodies as the first artificial production of motion by electricity, corresponding to the electric motor. I say artificial, because lightning has from the beginning of the world caused powerful movements and disturbances in the bodies which it strikes. Thus the birth of these two important machines was simultaneous; indeed, electricity was discovered solely by the fact that it produced motion under conditions which were peculiar, and it seemed to be so different from all other natural phenomena that from those early times, even up to the present day, it is looked upon as the most wonderful and mysterious agency in Nature.

The magnetic attraction of pieces of iron by the lodestone was also observed by the ancients, and the electric motor of the present day is more directly based upon this phenomenon than upon the electrostatic attraction caused by amber.

From those early times up to the present century, particularly during the last century, numerous experiments were made with magnetic and electrostatic attraction, but no one produced any results which can be considered to be any more like an electric motor than the simple experiments of the ancients. The first apparatus which in principle and construction sufficiently resembled the machines of to-day, to be properly regarded as an electric motor, was Barlow's wheel, described by him in his work on "Magnetic Attraction," published in London in 1823. This invention is remarkable in the fact that it antedated by eight years the disc machine of Faraday (which was the prototype of the dynamo), and his discovery of magneto-electric induction in 1831. Not only was Barlow's wheel far ahead of Faraday's disc in point of time, but it was also a much better construction, because the former was made in the shape of a star with long points, so that the current was confined to the particular portion of the wheel which was between the poles of the magnet. In Faraday's disc, on the other hand, the current produced in that part of the disc actually between the poles was at liberty to flow back through all the rest of the wheel. The armature was, therefore, completely short-circuited in itself, a feature which we know to be one of the worst faults that it can possibly have, and the amount of current obtained in the external circuit was an almost infinitesimal fraction of that produced, being only sufficient to deflect a galvanometer needle. It was, indeed, a fortunate thing for science that any perceptible effect whatever was obtained, otherwise the most important discovery of the nineteenth century might have been delayed.

Joseph Henry, in 1831, was the first to construct a motor which worked by electromagnetic attraction. This apparatus really has a better right to the distinction of being called the first electric motor than Barlow's wheel. Many other inventors followed Henry in devising forms of electromagnetic motors. Jacobi in 1834, Davenport in 1837, and Page in 1838, are particularly worthy of mention. Some of these early motors were by no means mere toys, but were of considerable size and power. Jacobi, of St. Petersburg, in 1838, propelled a boat 28ft. long at a speed of three miles an hour; and Page, of Washington, in 1851, succeeded in obtaining a speed of 19 miles per hour with a car carrying a number of persons and driven by a 16-h.p. electric motor. This result, by the way, is practically the same as that obtained from the most improved trolley cars of to-day, both in speed and power.

This brief glance at the early history of the electric motor brings out the striking fact that this machine was invented eight years before the dynamo and for several decades it was considered of more importance, both scientifically and practically; the motors of Jacobi and Page, for example, being far more powerful than any contemporaneous dynamo. A search through the patent records of the United States and England would show also that more attention and greater expectations were then based upon the motor. This was undoubtedly due to the fact that inventors hoped to obtain a source of power which would rival or surpass the steam-engine. It was gradually realised, however, that the cost of electrical energy obtained from a primary battery is so high that it cannot compete with a steam-engine. The number of pounds of zinc consumed in the best battery per horse-power hour is about equal to the weight of coal required to give the same amount of energy in a steam-engine; and since zinc costs about 50 times as much per pound as coal (in fact, it actually requires several pounds of coal to produce 1lb. of zinc) it is obvious that the primary battery is far more costly than steam in the generation of power. As a matter of fact, electrical energy from a primary battery at the present time costs at least 10 times and probably 20 times as much as that obtained by the use of a steam-engine and dynamo.

The realisation of this serious difficulty greatly discouraged scientific men and inventors in regard to the electric motor. A reaction set in against it, and for many years it was comparatively neglected by the best workers. The dynamo was taken up in its stead and developed in the remarkably rapid and successful manner which is the greatest practical achievement of recent times. The neglect of the electric motor continued until about 1887, the dynamo having by that time reached a state of great perfection and being in extensive use for electric lighting. The development of the dynamo, and the laying of electric light circuits through the streets of many cities and towns, provided the very supply of reasonably cheap current which was needed for the motor, and which the primary battery had failed to give.

This fact encouraged inventors and manufacturers to again take up the motor, and since that time its progress in this country has been very rapid; but even now the motor is somewhat overshadowed by the dynamo. The number of electric motors in use in foreign countries is not very considerable, but in the United States there are probably about 50,000 stationary motors and several thousand railway motors, whereas the number in the whole of Europe is not much more than one-tenth of these figures. This last fact probably explains why the literature of the dynamo is much more complete than that of the motor, since most of the books are written by Europeans—the time of Americans being occupied rather with making and using dynamos and motors than with telling others how to do these things. The most recent history of the motor includes the invention, by Tesla, in 1888, of the two-phase alternating-current motor and the development of the two and three phase systems. These important systems are now being practically used, and an enormous electric power transmission

* Lecture delivered before the Franklin Institute, Philadelphia, January 19, 1894.

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plant is being installed at Niagara Falls, which is to be operated by the two-phase system. Indeed, it may be said that the progress of the electric motor at the present time is equally as rapid as, and more interesting than, that of the dynamo.

If the dream of the electrical engineer should be realised and electrical energy could be obtained directly from coal without the use of the steam-engine and dynamo, then the importance of the electric motor would be paramount, and it would be used in practically every case where power is needed, while the steam-engine and dynamo would be relegated to scientific museums where they would be gazed upon as mere historical curiosities. This time may come in a few years, or perhaps not for centuries, but no one will dare deny its possibility, and many of the greatest thinkers and experimentalists are now working in that direction.

The points in the history of the electric motor to which I desire to call particular attention are these: that for many years it was considered of greater importance than the dynamo; that it then fell into a position of comparative insignificance, but that in the last few years it has again become very prominent, and in the future it is certain to be of still greater importance, while the dynamo may become obsolete.

In considering the construction and action of the electric motor, the first and most important fact is its great similarity to the dynamo, or, more strictly speaking, it is practically the same machine used in exactly the opposite manner. The dynamo is a machine which generates electric current when driven by mechanical power. A motor is a machine that develops mechanical power when supplied with electric current. Thus the functions of the two machines are exactly the converse of each other; nevertheless, identically the same machine can be used for either purpose—that is to say, the machine is perfectly reversible. It is also a fact that a machine that is good for one purpose is good for the other. The old idea that a good dynamo was not necessarily a good motor, and that considerable differences in construction are required, is, so far as the writer's experience goes, a fallacious one. The tendency now is for manufacturers to make exactly the same machine and use it for either purpose indiscriminately with only very slight differences in the details of winding, connections, etc.

While it is true that the two machines are practically identical in construction, nevertheless, their actions are somewhat different, and this difference is just sufficient to be puzzling. It seems to be a fact that knowledge concerning the motor is much less general and much less perfect than knowledge of the dynamo. The reason for this is probably that most persons fail to understand these slight differences in action, and are therefore apt to assume either that the two machines are exactly alike or entirely different, neither of which assumptions is correct.

The key to the action of the motor, and particularly to the difference between it and the dynamo, is its counter E.M.F. In the case of the dynamo there exists only one E.M.F., whereas in the motor there must always be two. The difference between the two cases may be expressed very simply in the following way:

One-kilowatt dynamo,

$$C = \frac{E}{R} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$10 \text{ amperes} = \frac{100 \text{ volts}}{10 \text{ ohms}}.$$

One-kilowatt motor,

$$C = \frac{E - e}{R^1} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

$$10 \text{ amperes} = \frac{100 \text{ volts} - 90 \text{ volts}}{1 \text{ ohm}}.$$

C is the current;
E the direct E.M.F.;
e the counter E.M.F.;
R the total resistance of the circuit;
R^1 the resistance of the armature.

The current and direct E.M.F. are the same in the two cases, but the resistance is only one-tenth as much in the case of the motor, the difference being replaced by the counter E.M.F. of 90 volts, which acts like resistance to reduce the current.

The counter E.M.F. of a motor is the necessary result of the rotation of its armature, as I will now show you by the following experiment. We have here two identical machines, one of them being connected to the electric light circuit, the current from which causes the machine to run as a motor. This machine is belted to the other machine, which is thereby driven as a dynamo. Now in both cases we have identical armatures revolving at equal speed in magnetic fields of practically the same strength. It is obvious, therefore, that nearly the same E.M.F. must be generated in each machine, because in both cases practically the same number of lines of force are cut by an equal number of turns of wire revolving at the same speed. In the case of the dynamo this E.M.F. produces a current which may be used to feed a certain number of incandescent lamps In the case of the motor the E.M.F. is opposed or counter to the direct E.M.F. of the electric light circuit, and the current produced is due to the difference between the two, as expressed in equation (2).

It may be asked why this E.M.F. is necessarily a counter one. The answer is that if we trace out the direction of the motion and of the lines of force, we shall find in every case that the E.M.F. generated is opposed to that which produces the rotation of the armature. This, in fact, necessarily follows from Lenz's law. The real significance of the counter E.M.F. is that it represents the amount of electrical energy that is taken out of the electrical circuit, so to speak, and converted into mechanical energy.

This is the way in which Nature always works in converting electrical energy into any other form of energy, with the single exception of the production of heat by the passage of current through a resistance. This last, however, is not a true case of conversion, being a frittering away of energy similar to the production of heat by friction. In all other cases the counter E.M.F. is always present. For example, when electrical energy is converted into chemical energy in the charging of a storage battery, or the decomposition of water, there is in every case a counter E.M.F. In the same way, when an electromagnet is charged and electrical energy is converted into magnetic energy, there is a counter E.M.F. which opposes the magnetising current, and is commonly known as the counter E.M.F. of self-induction. Even when electrical energy is converted into heat by the Peltier effect there always exists a counter E.M.F. which represents the conversion of energy; this being a reversible process, and therefore, a true case of conversion, which, as already stated, is not the case when heat is produced by mere resistance. This counter E.M.F. is indeed a most remarkable and interesting phenomenon, and throws considerable light upon the relation of the various forms of energy and the manner in which one is converted into another.

In the case of the motor, the counter E.M.F. actually represents the amount of electrical energy converted into mechanical energy, and therefore determines the efficiency, the so-called electrical efficiency, or conversion-factor, being equal to

$$\frac{\text{Counter E.M.F.}}{\text{Direct E.M.F.}}$$

The actual or commercial efficiency is somewhat less than this owing to friction, Foucault currents, and hysteresis. The counter E.M.F. also determines the speed and many other facts in the working of the machine.

In the minds of many persons the counter E.M.F. is thought to be merely a "scientific idea" or a mathematical abstraction which has no real existence or importance. Nothing could be more erroneous than any such opinion. The counter E.M.F. is just as real as the direct E.M.F. We have already seen that it must necessarily be produced whenever the armature revolves. It is somewhat difficult, however, to actually measure or show it. From its very nature it is covered up, so to speak, by the direct E.M.F. The ordinary way to determine it is to find the value of the direct E.M.F., the resistance, and the resulting current; the counter E.M.F. is then found by the following equation, which is derived from equation (2): $e = E - CR$. It is also possible to calculate it in the same way that the E.M.F. of a dynamo is determined, if the number of turns

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of wire, speed of rotation, and number of lines of force are known.

The following experiment actually shows the existence and value of the counter E.M.F. We have here a plain shunt-wound motor provided with a flywheel, and we run it from a constant-potential circuit of, say, 110 volts, and while it is running at full speed it is entirely disconnected from the circuit, but it will continue to run by the energy of the flywheel, and it will then act as a dynamo and generate an E.M.F. of nearly 105 volts, which is tested by connecting a voltmeter to the two brushes. This E.M.F. is practically identical with the counter E.M.F. which the machine was producing the moment before while running as a motor, provided, of course, the test is made immediately, so that the speed does not have time to fall appreciably. It should be remarked also that the strength of the field magnetism is slightly less, owing to the fact that it is fed by the E.M.F. of 105 volts generated by the machine itself, instead of by the 110 volts of the circuit; but if the magnetism is nearly saturated this will only reduce the number of lines of force 1 or 2 per cent. Several incandescent lamps can be connected in parallel across the terminals of the machine, and the energy in the revolving flywheel is sufficient to keep them glowing for one or more minutes. If a lamp is kept connected across the terminals of the motor while the switch controlling the circuit is alternately opened and closed, it is possible in this way to compare the direct and counter E.M.F. by the variation in the brightness of the lamp, and it will be seen that the latter is only slightly less than the former.

A still more striking demonstration of the reality of the counter E.M.F. will now be given by running the motor with a certain amount of resistance in its shunt field circuit, so that the field magnetism will be below its normal value, in which case the speed will be higher than usual. If the machine is now disconnected from the circuit, and the resistance is afterwards cut out of its field circuit, the E.M.F. produced will become actually higher than the original direct E.M.F.; in fact, it is possible to obtain two or three times the original voltage. We have here a new method of converting electrical energy to a higher potential, being a sort of direct-current transformer, which, however, is quite different in principle from the ordinary dynamotor.

The important matter of governing the speed or power of electric motors depends largely upon the phenomenon of counter E.M.F. For example, the various methods of regulating street-car motors—*i.e.*, the simple rheostat, the "loop" for short-circuiting one of the field coils, the "commutated fields," and the "series parallel controller" all act to adjust, or make up for, the variations in counter E.M.F. which result from changes in speed. The most awkward matter in working electric motors is to control the current when the counter E.M.F. is very low, due to the fact that the motor is starting or running slowly, and up to the present time there is no very satisfactory solution of this problem. The introduction of resistance in series with the armature is usually the simplest and most successful plan, but this is very wasteful of energy and involves the use of a large and clumsy rheostat.

The paradoxical fact that the speed of the ordinary shunt-wound motor increases if its field magnetism be weakened is also due to the counter E.M.F. This is easily understood if we remember that the counter E.M.F. is reduced by weakening the field magnetism, consequently the current is increased in strength, as is evident from equation (2), and the speed therefore rises until the counter E.M.F. reaches a sufficient value to shut off the excess of current.

The writer showed, several years ago, in his lectures at Columbia College, that a motor can easily be designed to run at the same, or at a higher, speed, when fully loaded than when lightly loaded. This may be done by slightly exaggerating the effect of armature reaction, so that the field magnetism will be considerably reduced by the large armature current which flows at full load, thus diminishing the counter E.M.F. and increasing the speed in the manner just explained. In this way the remarkable effect of greater speed with heavier load is obtained without any special device or construction, all that is necessary being a slight modification in design involving no increase in cost or complication.

These examples demonstrate the great significance and importance of the phenomenon of counter E.M.F. in the action of the electric motor.

THREE-PHASE TRANSMISSION PLANT AT TAFTVILLE, CONN.

The first important application of electrical power transmission to textile manufacture has just been installed by the General Electric Company at Taftville, Conn., the power being transmitted from Baltic to Taftville, a distance of nearly 4½ miles. It is a typical transmission by three-phase currents, in which motors of the synchronous type are used not only to operate one of the most interesting cotton mills in this country, but also the power station of the Norwich (Conn.) street railway. Mr. E. P. Taft, the founder of the Taftville cotton industry, long ago recognised the value of the available water power at Baltic, on the Shetugket River, near to which stood a ruined mill destroyed by fire some years ago, and having secured the property, with the water rights, determined to utilise the power as soon as a successful plan was offered.

Our contemporary the New York *Electrical Engineer* states that the Ponemah Mills are situated at Taftville, also on the Shetugket, and about three miles distant from Norwich. The original mill was operated for nearly a score of years by water power taken directly from the river, and when the new mill was erected it was found necessary to drive it from two 350-h.p. Corliss engines, the existing dam being insufficient in capacity. The generating station is at Baltic and the receiving station at Taftville. The rebuilt mill at Baltic contains in the basement the wheel and dynamo rooms of the generating plant The mill is of four storeys, built of stone, and will presently be used, as the Ponemah Mills, in the cotton-weaving industry. Four hundred feet above the mill a fine stone dam, 625ft. long, has been thrown across the river. The effective head on the turbines is 32ft., and the water available, even in the driest seasons, is sufficient to furnish not less than 1,500 h.p. The turbines are belted to pulleys on the main shaft, extending the whole length of the wheel-room, and continuing through the partition walls into and along one side of the generator-room. The pulleys are thrown into or out of action by Hunter clutches mounted with pulleys on quills, so that any or all of the wheels can be applied to driving the shafts. Similar pulleys and clutches are furnished in the dynamo-rooms for throwing in or out the various machines that may there be placed. The wheel-room contains three double 42in. horizontal wheels, and one double 27in. wheel, the former developing 800 effective horse-power each at 157 revolutions per minute, and the latter 300 h.p. at 244 revolutions per minute. The belts pass obliquely upward to the pulleys on the line shaft, and the turbines are kept at speed by Schenck electric governors, which have proved themselves capable of doing very fair service. The wheel plant and shafting were made and installed by the P. C. Home Company, of Gardiner, Maine. The line shafting is supported by heavy iron girders set on stone piers, and additionally braced by timbers.

The dynamo-room, beside the shafting, is occupied by two 250 kilowatt General Electric three-phase generators, delivering current on the line at 2,500 volts. Each machine is provided with its own exciter, a three-kilowatt bipolar dynamo. The three-phase machines run at 600 revolutions per minute, and are set so firmly on substantial foundations as to run with scarcely a perceptible vibration. The driving pulleys on the main shaft are fitted with Hunter clutches, so that either machine can be dropped out without the slightest disturbance to the service. The generators are connected to a common switchboard, and may be run in parallel whenever desirable. To this end the board is furnished with synchronising apparatus, the acoustic synchroniser being mounted on the face of the switchboard, and the equalising switch being at the back. The most interesting novelties in this switchboard are the high-voltage

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switches on the lower part of the board. These are mounted on marble bases with substantial barriers erected between the switch blades, so that the circuit at full load and voltage may be broken without the slightest danger of arcing across from point to point. They have been amply tested, and have proved their ability to cope with the trying work required of them with the greatest ease. The generators fall into parallel easily and run as smoothly together as would a couple of railway generators. No artificial load is used in throwing them together, none having proved necessary. The line is a good piece of construction work on substantial wooden poles placed 100ft. apart. The wires on the upper cross-arm are of No. 0 bare copper, and form the original three-phase circuit designed for the transmission. The wires on the lower cross-arm are No. 0000 insulated wire, and are four in number. They were originally intended for a railway circuit, the generators for which were to be installed at Baltic to feed the Norwich street railway, but as the amount of copper necessary to do the work successfully appeared too great, the system was changed, a second three-phase generator and motor were added, and three of the four proposed feeder-wires were utilised for the three-phase circuit. All are supported on standard oil insulators, the fourth, No. 0000 wire, forming a convenient relay in case of accident to any of the others. At Taftville the three-phase circuits are led into the basement of the new mill, where they drive two three-phase synchronous self-starting motors, identical in size with the generators at Baltic. These motors are belted to the jack shafting previously driven by the engine, the pulleys on the shaft being equipped with friction clutches, so that the load can be thrown from engine to motor, or back again, without any interruption of service. The motors start entirely unaided, coming up to synchronous speed in about 50 seconds from the time the current is thrown on. They are, like the generators, separately excited, the exciters being driven from the pulleys on the end of the motor shaft.

The efficiency of the complete transmission at full load from the power applied to the dynamo pulley to that delivered to the motor pulley is just 80 per cent. In originally starting the mill before the second motor was ready for operation, it was the custom to bring the motor up to speed, and then gradually throw in the clutch connecting it to the shafting already running from one of the engines. When the clutch was fully in and engine and motor running together, the engine was disconnected by its clutch and the power transferred entirely to the motor. This could be done without producing the slightest disturbance in the speed, and in the same way, now that both motors are in and the engines shut down, the load can be shifted from one motor to the other if desirable. Ordinarily, however, there is work enough for both, when driving the 1,700 looms in the new mill, operating the lighting plant and the three 80-h.p. General Electric railway generators, installed in another part of the basement.

THE ELECTRICITY USERS' ASSOCIATION.

The objects of the association are as follows :

1. To provide members and the public generally with expert advice on all matters connected with the use of electricity.

2. To protect the interests of intending users, whether members or not, by supervising the erection and maintenance of all electrical apparatus they propose to use.

3. To protect the interests of users by periodically inspecting all the electrical apparatus, etc., installed, thereby minimising the cost of maintenance and the possibilities of inconvenience in the future.

4. To protect the interests of those who are served by a supply company or from a central station against inaccuracies in their charges by periodically testing the meters.

5. To protect users from losses due to leakage or other drawbacks.

6. To provide users of electricity with every facility for using their apparatus to the best advantage and with the utmost economy, especially as regards boilers, engines, and accumulators, all of which are sources of considerable waste and unnecessary trouble and expense unless they are thoroughly and periodically examined.

The members of the association participate in all the above advantages together with :

1. The annual inspection of their electrical installation free of charge, provided that the number of lamps does not exceed 100. Beyond that number special arrangements can be entered into. Inspections are made annually, the first being usually carried out immediately the work is completed. After each inspection a written report, drawn up by the engineers to the association, is forwarded by the secretary. These inspections are particularly valuable, enabling the member to judge from the first report whether the work has been properly carried out ; subsequent reports would show whether the installation is still in perfect working order or deteriorating.

2. The association will undertake to keep the installation belonging to a member in working order, exclusive, of course, of lamp renewals, and do all the necessary repairs free of charge for a period of 12 months, provided the association is allowed to draw up the specification and supervise the carrying out of the work. The rate for such work is usually 5 per cent. on the total cost of the installation, but special charges, other than those set forth in the accompanying schedule, may be obtained from the secretary. Under this arrangement, the member is enabled to obtain tenders based upon the same standard from several firms, obviously to obtain similarity in the details of the tenders, without which a fair comparison cannot be obtained ; a further advantage being that the member is relieved from any expense (for the usual extras) beyond that specified in the original estimate. By this means the best return for the money expended is ensured, together with the satisfaction of having competent supervision.

3. A member may at any time have a further inspection made should he desire it on payment of a fee to be arranged.

4. Should a member who obtains his supply from any public source consider that for any reason he is not being properly charged, the association will enquire into the circumstances and report to the member. The fee for testing a meter is £1. 1s., unless further examination be necessary.

5. The association is prepared to act as surveyors of risks in which electricity is used for the fire insurance companies, and also to make periodical inspections during such time as the risk remains on the books of the company. Such inspections are very necessary, as in the course of years experience shows that the original number of lamps is increased, and the mains becoming overloaded, heating is liable to ensue. Fuses are also replaced by inexperienced persons, and in many cases it has been found that copper wire of as large a sectional area as the main itself has replaced the fusible wire, thus rendering the cut-out not only useless but a positive source of danger. Special rates are quoted for such work, which may be obtained on application to the secretary.

6. The association is also prepared to advise on any matters connected with the use of electricity. The association does not execute repairs, but reports the nature and extent of the repairs necessary and supervises their execution if required. The saving effected by having alterations and repairs executed under such supervision is a much larger amount than is generally realised. Where practicable, the contractor who has carried out the work is asked to do the necessary repairs.

Rules of the Association.

1. The association shall be called the Electricity Users' Association.

2. The offices of the association shall be at such place as the council may determine from time to time.

3. The association shall be constituted as follows: president, vice-presidents, general council, and ordinary members.

4. The objects of the association are as follows: (*a*) To promote and protect the interests of users and intending users of electricity in the United Kingdom. (*b*) To take

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such steps as the council may consider advisable to oppose fiscal or other legislation likely to be injurious to members, or restrict the application of electricity. (*c*) To provide members with expert advice on electrical matters generally.

5. A subscription of not less than one guinea per annum shall constitute membership of the association.

6. Any moneys received as annual subscriptions from members shall be applied to the payment of the expenses incidental to the general management and conduct of the association, and for the purpose of legal proceedings and other matters which may be deemed desirable to advance the interests of the undertaking. No liability shall attach to any member of the association beyond the amount of his subscription, and for this reason the association is being incorporated under the Companies' Acts. All receipts for subscriptions or other payments to the association shall be given only on the form specially prepared for the purpose and signed by the secretary, and particulars thereof shall be duly entered in the counterfoil. Every member on the payment of his subscription shall receive a copy of these rules.

The council may promote the formation of local branches of the association in all districts where such branches are likely to assist in securing the objects of the present association, or extending its influence and utility. The rules and by-laws of all such branches shall be approved by the council, and, subject to this provision, the members of such branch societies shall participate in all the advantages enjoyed by members of the parent association.

At the annual general meeting, the president and vice-presidents for the ensuing year shall be elected, who shall have the control and direction of the affairs of the society, as provided above. The council shall be summoned from time to time, as occasion may require, by the secretary. The notice of such meeting shall state the nature of the business for consideration. The president at all meetings shall have a casting vote. Three members of the council shall form a quorum.

In case of any dispute arising between any member and the association in relation to or in connection with the business of the association, the whole matter in dispute shall be referred to the president for the time being, whose decision shall be final.

Schedule of Charges—Engineering Department.

Particulars.	Current supplied from central station.	Users' own generating plant.
Examination of premises, preparation of specification and report thereon, and supervising installation during construction—		
Installation not exceeding 50 lights...	8 %	On amount of estimated cost.
50 and ,, 150 ,, ...	7 %	
150 and ,, 300 ,, ...	6 %	
300 and upwards	5 %	
Minimum charge	£2 2 0	... £4 4 0
Examination and report only upon specification submitted—		
Private houses, shops, etc.	1 1 0	... 1 11 6
Mills, factories, public buildings, etc.	2 2 0	... 3 3 0
Testing, examining, and reporting upon installations upon completion of contracts—		
Installation not exceeding 50 lights ...	1 11 6	... 2 12 6
50 and ,, ,, 150 ,, ...	2 2 0	... 3 3 0
150 and ,, ,, 300 ,, ...	2 12 6	... 3 13 6
300 and upwards	1% on contract.	

In addition to above, the association, as consulting engineers, are prepared to advise upon all matters connected with electrical work, and also to act as arbitrators upon questions of contract or other matters in dispute.

The following electrical engineers agree in the movement which has been inaugurated by this association: Messrs. W. P. D'Alton, London Electric Supply Corporation; Sydney T. Dobson, St. James's and Pall Mall Electric Light Company; R. C. Jackson, Newcastle-on-Tyne Electric Supply Company; Arthur Wright, Brighton Corporation Electricity Works; A. F. Barnard, Lancaster Corporation; J. T. Baron, St. Pancras Electricity Works; S. W. Baynes, Bradford Corporation; H. C. Buchanan, Weybridge Electric Supply Company; H. W. Cousens, Taunton Corporation; J. E. Edgcome, Kingston Corporation; F. Harman Lewis, Wolverhampton Corporation; A. H. Gebbings, Hull Corporation; W. E. Heenan, Northampton Electric Light Company, Limited; J. Hesketh, Blackpool Electric Light Company, Limited; W. D. Hunter, Newcastle and District Electric Light Company; J. A. Jeckyll, South Shields Corporation; W. Johnson, Sheffield Electric Light and Power Company; J. H. McLean, Oxford Electric Company, Limited; G. F. Metzger, Bath Electric Lighting Company, Limited; A. B. Mountain, Huddersfield Corporation; H. D. Munro, Exeter Electric Light Company; S. W. Newington, Oldham Corporation; G. W. Partridge, London Electric Supply Corporation; W. H. Patchell, Charing Cross and Strand Electric Supply Company; G. S. Peck, Scarborough Electric Light Company, Limited; H. Faraday Proctor, Bristol Corporation; G. Schultz, Notting Hill Electric Light Company; J. E. Stewart, Derby Corporation; H. Talbot, Nottingham Corporation; H. Tonge, National Electric Supply Company, Preston; F. F. Yeatman, Reading Electric Supply Company, Limited.

The solicitors to the association are Messrs. Windybank, Samuel, and Behrend, 35, Bucklersbury, E.C.; Mr. Charles H. Campbell, of 68, Victoria-street, S.W., is secretary (*pro tem.*); and the engineers are Messrs. Wilson and Clirehugh, of 3, Princes-mansions, London, S.W., and Temple-chambers, Brazenose-street, Manchester.

REVIEWS.

Electrical Measurements, and other Advanced Primers of Electricity. By Prof. E. J. Houston, A.M. The W. J. Johnston Company, New York; Whittaker and Co., London.

Electricity and Magnetism: being a Series of Advanced Primers of Electricity. By Prof. E. J. Houston, A.M. The W. J. Johnston Company, New York; Whittaker and Co., London.

Electric Transmission of Intelligence, and other Advanced Primers of Electricity. By Prof. E. J. Houston, A.M. The W. J. Johnston Company, New York; Whittaker and Co., London.

Prof. Houston has done good work in issuing these primers. He does not fall into the error of writing an advanced text-book and calling it a primer, but these papers are what they profess to be—full of instruction for that numerous class that desires to know the broad principles, to be able to utilise them in practice, and who do not desire to split hairs about the borderland of the subject. Prof. Houston, too, possesses the great advantage of having had considerable teaching experience, so that he knows what to say and what to leave unsaid. These excellent books should become as popular on this side the Atlantic as on the other.

Continuous-Current Dynamos and Motors. By Frank P. Cox, B.S. The W. J. Johnston Company, New York; Whittaker and Co., London.

We noticed the issue of this book in our number of November 3 last year, and have now merely to record it as having an English publisher. There is no doubt but that Mr. Cox has given a large amount of valuable matter, particularly intended to the younger students, in this volume.

The Popular Handbook of Finance. By A. Baines. Published by Saxon and Co., Bouverie-street. Price 1s.

In these days of limited companies and co-operative stores, when everybody who has a shilling to invest does invest it and does not follow the old-fashioned plan of keeping a snug sum of various coins in an old stocking hidden up the chimney, a book of the excellence of the one before us is certain of a wide approval. The information it contains is what everybody usually wants and is just as usually unable to find. To business men, and especially to those who have not been educated in a bank or a counting-house, the book will be invaluable. It will no doubt be looked upon as a book of general reference, as the price, being only a shilling, should ensure a very large sale. We cannot say that it contains anything electrical, except indirectly it tells us a good deal about limited liability, banks, bills, and so on; and if company work is not interesting to electrical shareholders it ought to be, seeing how great a part of the trade is carried on by such companies.

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THE
ELECTRICAL ENGINEER.

Published every Friday.
Price Threepence; Post Free, Threepence Halfpenny.
Editorial and Publishing Offices:
139-140, SALISBURY COURT, FLEET STREET,
LONDON, E.C.

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TO CORRESPONDENTS.

All Rights Reserved. Secretaries and Managers of Companies are invited to furnish notice of Meetings, Issue of New Shares, Installations, Contracts, and any information connected with Electrical Engineering which may be interesting to our readers. Inventors are informed that any account of their inventions submitted to us will receive our best consideration.

All communications intended for the Editor should be addressed C. H. W. BIGGS, *139-140, Salisbury Court, Fleet Street, London, E.C. Anonymous communications will not be noticed.*

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BOUND VOLUMES.

Vol. XII. of new series of "THE ELECTRICAL ENGINEER" can be had bound in blue cloth, gilt lettered, price 8s. 6d. Subscribers can have their own copies bound for 2s. 6d., or covers for binding can be obtained, price 2s.

BLUFFING AND HEDGING.

The letter of Sir John Pender to Sir Charles Tupper, which appeared in the *Times* of Wednesday, is exactly what we expected of the man. One paragraph carries out to the full our prognostications of some years back. At that time we suggested Sir J. Pender and his colleagues would exert themselves in every possible way to stop the Pacific cable. We at the time gave extracts from correspondence with their agents "down under" and others to show the methods adopted of educating the Press and public opinion to their views. At the same time we said that if the Pacific cable was inevitable, and their opposition failed to stop it, they would try to move heaven and earth to get it under their own control. This is exactly what is coming to pass, but the opposition has delayed matters till even for strategic purposes a new decision will have to be taken. France has stepped in while Englishmen have been squabbling, and if the Pacific cable is laid, it will either be to connect with the French or entirely independent. Which? is the question that has to be decided. Once more we reiterate the fact—and we in this case know exactly how far we may venture to speak—that the aim of Sir J. Pender and his friends has never had but one object—neither philanthropic nor patriotic, but immediately and intensely selfish. From first to last Governments have been played off against each other, both as regards mother Governments and colonial Governments, in order to consolidate and confirm a monopoly. Far be it from us to condemn this action from a purely business point of view. The greatest credit is to be given to Sir J. Pender and his colleagues for having so long kept competition at bay. If it were not for the one thing, that, in our opinion, they have never catered for their shareholders, but only for themselves, we could have no word against this policy from that particular point of view. It is, however, our firm belief that Sir J. Pender and his friends have enough of human nature in their constitutions to know that if they consistently pay five or six per cent., their management will not be too closely scrutinised. They will bluff or they will hedge, whichever suits their purpose. Now, we contend that from an Imperial point of view their system is vulnerable at every point. The late Sir James Anderson contended otherwise. He argued that loops along the coast from port to port were more easily maintained and repaired in troublous times than long lengths of deep-sea cable, and he was right, with an "if" given in. We insist that both ends of the cable must, for strategic purposes, be in the hands of ourselves or our friends, and not one end in our own hands while the other is possibly in the hands of our enemy, or with a sympathiser with the enemy. We quite agree with the difficulty of keeping intact a deep-sea cable against a powerful enemy determined to destroy it. Possibly our conclusions are wrong, but it seems to us that the greatest value of a cable under our own control would be in the early days of a conflict—just before and just after the final rupture. Given such a cable, every point of our empire would be prepared for hostilities, and though the destruction of a cable

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after might be very inconvenient, it would have enabled the authorities to give warnings. If, however, there is no cable so controlled, these warnings would probably be impossible, or would be as well known to enemies as to friends. Sir John Pender's latest move is as 'cute as his moves usually are. It is to attempt to underbid possible rivals. We extract that particular paragraph of his letter to which we refer. It is as follows:

"If, however, the Governments concerned consider a second cable is required for strategic purposes—which I very much doubt—they must, of course, pay for it, and, as I have frequently stated, my company would be quite prepared to undertake the work on fair and reasonable terms, which terms would necessarily be more favourable to the Governments than could be obtained from any other company, owing to the exceptional facilities possessed by the existing system."

Probably, however, the voice of the charmer will, like the voices of the syrens in the olden legend, fall upon ears stuffed with materials to keep out the seducing vocal effort. At any rate, our view of the case is to have nothing to do with Sir J. Pender or any company with which he is directly or indirectly connected. If the matter falls under his control, depend upon it he will so fashion matters as to remain master of the situation.

THE ELECTRICITY USERS' ASSOCIATION.

Not many years ago sanitary engineering was in the happy-go-lucky position of being able to "go as you please." Drains were laid or not laid with a beginning and no end, or an end and no beginning. Nothing seemed very particular, and the result was usually typhoid fever. Suddenly, men began to agitate, and found out that bad drainage was, to say the least of it, unpleasant. Sanitary engineers, following Shakespeare's advice, and taking the frightened community "at the flood," managed "to lead on" to their individual fortunes. If we recollect rightly, an association was formed so that the householder paying a small amount could have his drains thoroughly examined and certified, and by the payment of a small annual amount could have them periodically examined. We do not know whether this action of the sanitary engineers gave the idea to electrical engineers to promote the association the title of which is given above, but the objects of the two associations are somewhat similar. The Electricity Users' Association professes to do for the users of electricity what the sanitary engineers profess to do for the householder—namely, to test apparatus and advise upon technical questions. The proposed association must be viewed from two standpoints: (1) the real views of the originators, (2) whether the public will obtain value for its money.

It is clear that the promoters of this association have had in their minds the obtaining of business by legitimate means—that is, while not acting unprofessionally, increasing their *clientèle* and giving full value for money. No doubt some critics will say the whole proceeding is unprofessional. We do not agree with this view, although, as is well known, we have strong opinions about the more extended use of the consulting engineer. But there are engineers and engineers, and we do not deem it unprofessional for an electrical engineer to become the consulting engineer to a company whose object is not only ostensibly, but really, to benefit the public. If the association is but moderately successful, the first result of its action will be to condemn a good deal of jerry wiring. The general public has yet to realise there are two ways of installing the electric light in houses—one (multitudinous) cheap and nasty, the other good and creditable to the installers. Unfortunately, too often the question of five pounds cheaper decides between a firm which has no reputation and one which has, and not in favour of the latter. Now, an association such as is proposed should be utterly independent of this firm or that firm, and should have one standard for all. We can quite understand that periodic inspection, if the recommendations made are duly carried out, will lead to a greater saving than the cost of inspection and alteration. Without going into detail, it is easily seen that slight leakages, meters out of repair, and such like things, may add largely to the bill, but not to the light. In fact, a concrete example will show that it may be greatly to the advantage of the user to pay his guinea and have advice. The other evening, while in the *foyer* of a theatre, a gentleman who used the electric light from the House-to-House Company's supply—Kensington way, was commenting upon the greater length of his bill during one quarter over that of the previous quarter, although he maintained that only the same number of lamps were used, and had been in use, he contended, a less number of hours during the quarter in which his bill was heaviest. Had the increase been small it would probably have passed unnoticed, but it was not small. Ordinary consulting work can hardly be said to touch such matters as this, and the field may well be filled by an association of the kind proposed. The promoters, as we say, hope to increase their business. In discussing one point we have necessarily trespassed upon the other point, and properly worked the public undoubtedly ought to get full value for its money. We have elsewhere given the full text of the objects and rules of the association with the schedule of charges. No doubt the rules will have to be varied, and the schedule of charges will not pass unchallenged, but these matters do not concern us at present. The important question in the first place is to ascertain whether the principle is to be adopted.

ELECTRICITY IN HEAVY RAILROAD SERVICE.

We have received a copy of a paper on the conditions of use of electric motors on the present steam railroads, read by Mr. D. L. Barnes at a recent meeting of the Western Railroad Club. Awaiting the preparation of engravings for use in extended abstracts from the paper, we give a short synopsis of the principal points.

Mr. Barnes first discusses the question of direct current

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and plain motors and alternating currents and multiphase motors. He says that it is the hope of electricians that multiphase motors may become more practical than at present, for they have some advantages over the plain current motor, the principal one being simplicity of construction. But the alternating-current motor is not yet developed to such a point as will permit safe conclusions as to its final adaptability to railroad work, though it is probable that it will eventually be used for long-distance high-speed work. For the present, however, the plain current motor is useful, but the limit of its use for railroad work is found not so much in the motor itself or kind of current as in other matters.

The electric motor is, as compared with the steam locomotive, a simple machine, and the repairs must be correspondingly small. It has no valves to leak, boiler to get clogged with scale, firebox sheets to crack, grates to burn out, screw stays to break, crown sheets to come down, and so on through the list of annoyances to which the steam locomotive is subject. Therefore one great reason why electric motors may eventually take the place of steam locomotives will be found in the simplicity of construction, operation, and repair.

There are yet, however, serious problems to solve. One of these is that of collecting the current from the conductor. This is solved for low speeds, but for 60 miles an hour and upward it is still in question. However, there will probably be no great difficulty in arranging this matter. Another question is that of connecting the armature and axle. For the present, electricians generally have settled down to the use of gears, although motors like that on the Liverpool Overhead have been designed in which the armature shaft is the axle of the driving wheels. Electricians are still working on the problem of getting a variable connection between a revolving armature and a driving axle.

A careful analysis is made of the efficiency of plain current motors with positive connection, but this analysis cannot be intelligibly reproduced without the diagrams. It may be said, however, that the locomotives of elevated or suburban roads are constantly putting energy into a train up to the point of application of brakes, when it is immediately taken out by the brake shoes and wasted. It has been proposed to reconvert this energy into electricity during the process of braking by using the motors as dynamos, but no practical plan for doing this has yet been devised. It appears, however, from the investigation that for this kind of work the electric motor is best adapted to give good commercial results. The efficiency of the conducting line from the central station to the motors ought to be 90 per cent., that of the dynamos ought to be such as to give at their terminals a current that would represent 85 per cent. of the indicated power of the steam-engines, and the steam-engines ought to give 1 h.p. with 15lb. of steam an hour. Using the same sort of fuel on the steam locomotive as is used under the stationary boilers, and assuming it to be fair bituminous coal, each pound should evaporate into steam about 6lb. of water in the locomotive, or 8½lb. in a good stationary boiler, and the steam locomotive will generate 1 h.p. for about 25lb. of steam an hour when the locomotive is of the best type. On this basis, comparing the indicated power in the steam-cylinders of both systems, we have 1·8lb. of coal per horse-power per hour in the stationary engine, and 4·2lb. of coal per horse-power per hour in the steam locomotive. But the steam locomotive uses the power directly, and there is no further loss that has to be considered in the comparison. With the electric system there is a further loss of 15 per cent. in the dynamo and connections, 10 per cent. in the line, and 50 per cent. in the motors for switching suburban and elevated railroad work, or 20 per cent. in the motors for lines having about eight minutes between stations. The final result is the delivery of about 30 per cent. of the efficiency in the cylinders of the stationary engine, at the drawbar of the motor, for switching, suburban and elevated railroad work and 61 per cent. for the longer line assumed. The result figures out, then, 4·7lb. of coal an hour in the stationary engine for one useful horse-power delivered at the drawbar of the electric motor for short lines, which is practically the same as that required for the steam locomotive; for the longer line assumed the fuel consumption would be 3lb. an hour per useful horse-power. This is based on ordinary fuel. With anthracite burned on large grates the locomotive will do better work in proportion, and the difference in economy of fuel will be in favour of the steam locomotive on the short lines.

In elevated railroad work, using anthracite coal and compound locomotives, we may take 3½lb. of coal per horse-power per hour at the drawbar. Hence, considering only the use of fuel in actual work, there would be no saving in the weight of fuel by using electricity.

The conditions vary so much that each case must be treated by itself, but for practical comparison we may assume that the same weight of fuel per ton-mile would be used with the electric system as with the steam locomotives for short lines. If the conditions are such that a cheaper kind of fuel can be used at the central station than on the steam locomotive, there may be a considerable saving in cost of fuel, while there is none in the weight. In short, the conditions which regulate the price control almost entirely the saving in fuel cost incident to the use of electric motors. For long runs also it appears that the average conditions are such that the same weight of fuel would be used per ton-mile, and it is only where a higher priced fuel is required for the steam locomotive than for the central station that any substantial saving in fuel cost could be made.

The first cost of central-station plants and conductors for long-line work is so great per mile of track that the companies must for the present hesitate to make the experiment of changing, and prices are so unsettled that it would be valueless to attempt any estimate of the cost of changing a large steam locomotive plant to an electric one; but it would not be surprising if a year hence the cost of installing an electric plant for long-distance work would be half what it was a year ago. Only on short lines where the traffic is crowded is it now economical to substitute electric motors for steam locomotives.—*Railroad Gazette.*

DYNAMO PATENTS IN CONNECTION WITH NIAGARA.

Three patents were issued on the 1st inst. by the United States Patent Office to Prof. George Forbes, which are said to embody some of the principal features of the 5,000-h.p. dynamos about to be installed at Niagara, and which were discussed in Prof. Forbes's paper read before the Institution of Electrical Engineers.

One of the patents, according to the *Electrical Engineer* of New York, describes very clearly the objects which had to be attained. The first object was a possibility of winding the machine to get a high E.M.F. as safely in the machine itself as in a step-up transformer. This can be done in a large machine of 5,000 h.p., where the space occupied by insulation need not bear the same proportion to the space occupied by wire as in a smaller machine, and where oil circulation can be employed. It can be accomplished by having the armature stationary, especially if the shaft be vertical. The position has been taken up by Prof. Forbes that it is possible to do away with the cost and losses in a step-up transformer, that the large stationary armature is as safe to wind as is the step-up transformer, and if the difficulty of using very high electric pressures in the dynamos be shirked it must be faced in the transformer.

The next three objects were all attained by one simple expedient. These were (1) to get mechanical security having in mind the enormous centrifugal forces at a speed of 250 revolutions a minute, (2) to have a maximum of flywheel momentum with a minimum of weight, and (3) to prevent the magnetic pull from assisting centrifugal force to rupture the revolving part. These were all attained by the simple expedient of making the revolving fields external to the armature.

It is said that every one of the designs submitted to the Cataract Company had a separate flywheel, which increased the weight to be supported by the hydraulic piston in the turbine beyond what it was capable of supporting. In all

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the designs the magnetic pull between the field poles and the armatures helped centrifugal force to break the revolving part, and in those with revolving fields the field coils were held in by pole faces held in place by bolts and keys—a source of weakness considering the high centrifugal forces.

Owing to the great diameter of the revolving part there is a maximum momentum with minimum weight, and all need for a flywheel is done away with. When the load is removed, and while the turbine governor is cutting off the water, this enormous momentum prevents the machine from varying its speed unduly. Moreover, the magnetic pull between the pole-pieces and armature diminishes very appreciably the tendency of the centrifugal force to break the flywheel; while the pole-pieces and their coils are all held securely by the centrifugal force against the interior of the ring which forms at once the flywheel for the turbine governor and the yoke for the field magnets. Further, the central armature, being fixed, can be wound for very high electric pressures.

Of the two other patents issued at the same time to Prof. Forbes, one refers to the notching of the armature to hold two types of coils which overlap each other; and the other a method of enclosing the armature coils with an envelope and circulating oil through the coils, to carry off the heat and to provide for high insulation.

THE GLASGOW CORPORATION ELECTRIC LIGHT STATION.

Pressure on our space has hitherto prevented us from dealing with the paper read by Mr. Wm. Arnot, A.M.I.C.E., before the Institution of Engineers and Shipbuilders in Scotland on "The Corporation Electric Light Supply." We, however, now append the following abstract of the paper and discussion thereon.

The provisional order obtained August 14, 1890, gave the Corporation two years to carry into effect the powers granted therein. Lord Kelvin was consulted October 9, 1891, and his advice was most decided on the advisability of supplying with a direct current at not more than 200 volts. It having been decided to adopt a low-tension three-wire system, Prof. A. B. W. Kennedy, F.R.S., was requested on November 12, 1891, to prepare a scheme. A site was obtained in Waterloo-street, at the corner of Mains-street, and the contract for the building was signed on April 7, 1892. On Saturday, February 25, 1893, the arc lamps on the principal streets were first lighted, and the current was switched on to the incandescent mains on Saturday, April 22, 1893.

My paper on this subject would be incomplete without reference to the work carried out by Messrs. Muir, Mavor, and Coulson, Limited, previous to that date. Of the commencement and details of their work it is not necessary for me to trouble you. Suffice it to say that on March 1, 1892, the Corporation purchased the plant of that company, which was then supplying from John-street an alternating current at 2,400 volts on the mains. These mains were all overhead, and the lamps were supplied at 100 volts, the pressure being reduced by means of a transformer in each consumer's premises. On the date of the purchase there were 36 consumers, taking current equivalent to the supply of 5,000 8-c.p. 33-watt lamps. The Board of Trade granted permission to the Corporation to continue the use of these mains on the condition that they should all be removed by August, 1893. To transfer the customers from the high-tension overhead mains to the low-tension underground mains was the first duty of the staff. This was done at the rate of about three per day, and John-street station was shut down on May 11, 1893. The site at Waterloo-street station measures about 31 yards by 31, and contains 972 square yards, having Waterloo-street to the north, Mains-street to the west, and Wellington-lane to the south, and a tenement of offices on the east side. The building stands on a layer of concrete 2ft. thick, laid throughout the entire block. The main building stands fronting Waterloo-street, and covers half of the ground. It consists of the engine-room, first floor with offices and workshop, and second floor with laboratory, drawing office, meter-room, and cable floor. Behind the main building is the boiler-house, with the battery-room above it.

Boilers.—These consist of six marine-type steel boilers, measuring 12ft. long and 10ft. in diameter, working at a pressure of 160lb. They have each two furnaces of the corrugated type, with an internal diameter of 3ft. The fire-grates are 5ft. long. There are 194 wrought-iron lap-welded tubes in each, 2¾in. external diameter and 8ft. 6in. long, between the tube plates ⅛in. thick, stay tubes ¼in. thick. A steel steam-drum, 5ft. long by 18in. diameter, is on each, with two 5in. stop-valves. The mountings are very complete, being two safety-valves, two automatic water-gauges with plate-glass guards, two shut-down feed-check valve, blow-off cock, scum cock, 12in. diameter steam-pressure gauge, attachment for test pump, attachment for engine indicator. These boilers were all tested and passed by the Board of Trade inspector. A smoke-box is on the front of each boiler connecting the tubes to an uptake which communicates with the main flue. This is led into the chimney at a height of 15ft. There are no underground flues. Each boiler is covered with 2½in. composition, and stands on two cast-iron brackets. There are two Tangyes (steam 7in., water 4½in.) pumps, each capable of delivering 4,800 gallons per hour, either through a Wright's feed heater or direct. There is an injector connected to the cold feed capable of delivering 5,000 gallons per hour. The water-tank has a capacity of 3,500 gallons. The steam-pipes are 7in. and 8in. diameter, steel, lap welded, with wrought-iron flanges screwed and brazed. In the engine-room the steam-main forms a complete ring, slung by means of rods from cast-iron brackets. Four of the boilers have a duplicate connection to this ring, the remaining two have one connection.

Engines.—These are Willans central-valve compound engines, of the following particulars: Two size G G.—Number of cranks, two; diameter of low-pressure cylinder, 14in.; high-pressure, 10in.; stroke, 6in.; revolutions per minute, 450; i.h.p., 78. Two H H S.—Number of cranks, two; low-pressure cylinder, 17in.; high-pressure, 12in.; stroke, 8in.; revolutions, 370; i.h.p., 160. Three I I S.—Cranks, two; low-pressure, 20in.; high-pressure, 14in.; stroke, 9in.; revolutions, 325; i.h.p., 222. Two I I I S.—Cranks, three; low-pressure, 20in.; high-pressure, 14in.; stroke, 9in.; revolutions, 350; i.h.p., 360; steam pressure 150lb.; the cranks of the duplex engines are set opposite at 180deg., the triple at 120deg. The engines are single acting, with a receiver between the high pressure and low pressure. The valve-rod eccentric is placed in the centre of the crank. There are two connecting rods, one on either side of the valve rod. The piston rod is hollow and contains the steam-ports. The valve rod works in the centre of the piston rod. The cross-head is contained in a trunk piston, which act solely as a guide, and by means of which the pistons are cushioned on the up stroke. Air is admitted above this piston by the ports on the guide cylinder; this is compressed and expanded again on the stroke.

Dynamos.—The dynamos are two-pole shunt-wound, with drum armatures. They are coupled direct to the engines, with a heavy disc to ensure steadiness in the running. The combined plant stands on one sole-plate. The maximum output of the several dynamos is: two 330 amperes, 140 volts, 92,400 watts; two 400 amperes, 230 volts, 184,000 watts; three 670 amperes, 230 volts, 462,300 watts; two 980 amperes, 230 volts, 451,200 watts; making a total of 1,189,900, or 1,190 units. The absolute necessity of working without making any smoke has led to the use of gas coke, obtained from the Corporation gasworks. At a preliminary trial on one boiler, in April, 1893, when working with a very light load, the water evaporated was 27,458lb. in eight hours; 3,770lb. of coke were used. Mean boiler pressure, 149; mean feed temperature, 145deg.; evaporation per hour, 3,432lb.; actual evaporation per pound of coke, 7·28; reduced to standard, 8·13. The value of this per unit generated was ·24. The analysis of the coke showed: moisture, 10·68; ash, 10·16; loss on ignition, 79·16. Assuming this to be carbon, it gives 11,416 thermal units per pound. The result of measurement in a calorimeter gave 11,286. It may therefore be taken that the evapora

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tive value of this coke is 11·75lb. of water under standard conditions. These figures do not take account of the coke used at night when no work is being done. The trial only lasted for eight hours. An extended test was made by Prof. Kennedy on November 2 and 3, when the following results were obtained:

Total duration of experiments ..... hours	48
,, coke put on fires ..... lb.	61,900
,, coke used in boilers of which the stop-valves were closed ..... lb.	9,260
,, net coke used for steam ..... ,,	52,640
,, water through meter, allowing for all differences of level ..... lb.	378,970
,, water used while station was shut down ..... ,,	16,296
,, net water used during running hours ..... ,,	361,674
,, electrical work at dynamo terminal ...e.h.p. hours	8,991
Total electrical work at Board of Trade units, or kilo-watt-hours	6,708
Pounds of water evaporated per pound of coke put in fire, actual	6·12
Pounds of water evaporated per pound of coke put in fire, reduced to standard	7·38
Pounds of water evaporated per pound of net coke, actual	6·87
Pounds of water evaporated per pound of net coke, reduced to standard	7·91
Ratio of stand-by fuel to total fuel on fires, per cent.	14·96
Pounds of water used per unit generated	56·5
,, ,, ,, net water only	53·93
,, ,, per e.h.p. hour	42·14
,, ,, ,, net water only	40·2
Pounds of coke put on fires per unit generated	9·23
,, net coke used	7·85
,, coke put on fires per e.h.p. hour	6·88
,, net coke used	5 85
Total running hours during the two days	33·75
Mean load during running time ..... kilowatts	198·7
Maximum load ..... ,,	669·4
Ratio of mean to maximum load ..... per cent.	29·7
Load-factor per actual hours and engines ..... ,,	68·4
Mean steam pressure, pounds per square inch above atmosphere	151 5

During two days' trial the total coke put on the fires was 61,900, but of this 9,260 was required to supply damped fires and condensation in the steam-pipes through the night. The main steam-pipe is always under steam for the sake of the joints. The ratio of 14·96 per cent. between these figures is rather high; the water consumption is much too high. These figures will be improved, faulty traps and drain cocks being responsible for much of the loss.

The engines and dynamos combined show an excellent efficiency. The efficiency curves were taken by Prof. Kennedy at Thames Ditton before delivery here. The curves for the last large set were thought to be too good to be correct, being 88 per cent. for the combined plant at full load, a loss of only 12 per cent. between the indicated horse-power on the engine and the electrical horse-power delivered at the terminals of the machine. Before accepting the results all the indicator springs were independently tested and found correct. The results were therefore accepted. The consumption of water per indicated horse-power was 17·5lb. for every horse-power added after 40 i.h.p., which is required to drive the engine and dynamo. These curves show that with an engine load-factor throughout the station of 50 per cent., or half load, an efficiency of 80 per cent. can be maintained in the generating plant.

Accumulators.—A set of accumulators is placed over the boiler-house. This position keeps them in a suitable temperature; otherwise during the winter they would be affected by frost. The set consists of 114 cells, 57 being placed between the negative wire and the middle, and 57 between the positive and middle. Each cell has 61 lead plates, with a capacity of 1,000 ampere-hours at two volts, with a discharge rate of 200. There are six cells as repair cells, or, as they are sometimes called, milkers. From these, plates are taken to replace faulty ones in the working set, and should a cell show any weakness it is not allowed to discharge for a day, but is short-circuited by two milkers in series. It has thus four volts across it. The battery regulating switches are placed in the battery-room, and controlled by bevelled gearing from the switchboard.

Distribution.—The distribution begins practically at the switchboard. It is generated at from 210 to 230 volts, and is kept constant at the feeding points at 205 or 102 on each side of the system. The balance is maintained in the station by means of two 100-volt machines. The difference in current between the two sides does not generally exceed 200 amperes at any load. Exceptional nights have been known, such as 650 amperes, when both machines had to be run on the one side. I have put before you curves showing one of the heaviest days, and one of last month, which shows a falling off. The load-factor for these days is noted on each. This factor is the ratio between the total output and the possible total output if the plant were working full load for 24 hours. I have also noted the ratio between the amperes of current applied for and the maximum output. In December it was 54·3, and February 37·1. The real efficiency of running is shown in the plant load-factor, which in February was 68·5 per cent. It has been as high as 71 per cent. This factor is the ratio between the output and the possible output if the machines were run full load from the time each one is started till stopped. This is the percentage that tells on the costs of running, fuel, water, oil, etc. The lamp connections have progressed in a fairly steady curve. October has the largest number of applications. The maximum output has not reached more than 54 per cent. of the total lamps wired.

The underground work in the streets is, I presume, pretty well known to you. The copper strip is laid on porcelain insulators in iron culverts, which are watertight. I do not mean that under a pressure they would keep out water, but owing to their construction, the lids overlapping the culverts, the ground in which they lie must be flooded before the water could rise high enough to enter through the seam. I have never known an instance of water in the culverts. Water does collect in the brick junction-boxes, especially in Bath street, and districts where we have heavy clay soil. Provision is made in all such for their thorough drainage. Where it is not possible to lay copper strip, indiarubber-covered cables have been laid in cast-iron pipes. In distributing by three wires a network of copper is laid down. There are, generally speaking, three wires on each side of the street; in some cases there are only two wires—positive and middle on one side, negative and middle on the other. Where strip is laid the positive is always next the building, and the negative always outside. Where cable, the positive is painted blue, middle white, and negative red. The entire network is connected together throughout the city, positive to positive, middle to middle, and negative to negative. The current to this network is conveyed by means of what are termed feeders; these are marked green on the map, and are so constructed on their sectional area as, when fully loaded, to give an equal drop in the potential. There are only two conductors to each feeder—one positive and one negative. The middle wire of the network, or distributing mains, as we call them, is brought back to the station from several points, and has a sectional area of 1in. at the station. The potential is maintained constant at the points where the feeders join the network; it is therefore necessary to raise and lower the potential at the station to compensate the rise and fall of the load. For this reason, no house connections are taken from the feeders. All are taken off the distributing mains. As a rule, only two wires are taken into each consumer, either from the positive and middle, or negative and middle. Every care is taken to balance the two sides—that is, to have as many lamps connected to the one side as the other. Not only in the number of lamps has this balance to be maintained, but also in the class of customer. Early shops must be balanced against early shops, and late against late, houses against houses, and clubs against clubs. Where a large quantity of current is required, we balance such a building in itself, and take three wires to the main switchboard, where the division is effected. The joints, which are perhaps the most important in the cable mains, are all vulcanised, thus making them equal to new cable. It may be interesting to you to learn that I have some of the indiarubber cable placed underground that was used by Messrs. Mavor and Coulson overhead, and purchased by them five years ago. It seems as good and tests as well as new cable. Faults in the underground mains are easily found by means of a compass needle. The needle is placed on the faulty conductor and brought to be parallel with it by means of a strong directing magnet. The other conductor is flashed to earth, and the direction of the excess current

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due to the fault is noted. In this way it is easily traced. Nearly all the faults are caused by careless workmen. The last fault was in Renfield-street on the middle wire, and was traced in half an hour.

There are now 382 consumers, who have applied for a current of 15,487 amperes, which represents, roughly, 46,460 8-c.p. 33-watt lamps, distributed somewhat as follows:

	Shops.	Ware-houses.	Offices.	Churches.	Private houses.	Clubs, hotels, and theatres.
No.....	242	21	91	3	12	13
Amperes...	7,776	2,680	3,269	229	275	1,258

I have endeavoured to lay before you in as concise a form as possible a description of the works and plant in use at the Corporation electric lighting station. We have not had a year's run yet, and it is therefore impossible to give figures as to cost of production, etc. The author would take this opportunity of stating that the successful issue of the winter's labour has been due, in a very great measure, to the working staff. They have spared no pains nor trouble. The work has been their first consideration. From the highest to the lowest all have worked well.

Discussion.

The **President** said it was rather difficult to discuss this paper adequately, bristling as it was with figures, but he hoped that some of the electrical experts present would start the discussion. The mention of Prof. Kennedy's name as consulting engineer to the Corporation electric lighting reminded him that the University of Glasgow had seen fit to confer upon him the degree of Doctor of Laws. He was one of their honorary members, and he thought it showed the discrimination with which their honorary members were selected.

Mr. Mavor said that although he considered the system adopted by the Corporation unsuitable for the work to be accomplished, he wished to compliment Mr. Arnot on the successful starting of the Glasgow electrical station, and to say that, watching critically the result of their work, he could do nothing else than say that it had been so far successful, and that the Corporation were giving the public a thoroughly satisfactory supply of electricity. The company with which he had been associated had the honour of applying for a provisional order before the Glasgow Corporation did so. In doing so they worked out a scheme for the lighting of Glasgow which differed very materially from the one now being carried out. The principal difference was that they considered that in attacking the problem of lighting the city, they must look at it not so much from the immediate position as from the probable future requirements of such a city as Glasgow. Now, that was a very large and difficult problem, and in making up their minds on the subject they devoted much care to the question, and used as much as possible the experience which had hitherto been gained upon this point. He regretted to say that Lord Kelvin diametrically differed from them, although he was their consulting engineer, as to the advisability of using high-tension alternating currents. He would not attempt to discuss the reasons here, but he thought it was not difficult to see why the Glasgow Corporation were advised to adopt continuous currents in the circumstances in which they were placed. As Mr. Arnot had pointed out, the Corporation allowed a very large amount of the two years allowed by the Board of Trade to elapse before they took any steps in the matter at all, and it had to be admitted by the most ardent advocates of the alternating-current system that it was not then so well developed as the continuous-current systems for application to public lighting. A very large amount of work had been done by the Glasgow Corporation on a system almost precisely similar to that adopted in America by the Edison Illuminating Company. They had done an amount of work which was enormously greater than anything done in alternating currents, and the experience gained handicapped the alternating currents in the race, because they were later in coming on the field; but in these days he thought no one would venture to dispute that the high-tension alternating current was making its way forward, and that the engineers who had the necessary experience to enable them to compare it with the low-tension continuous currents thought that the day was not very far distant when no one would hesitate to use high-tension alternating currents in districts which were so eminently suited for such an application as the district which the Glasgow Corporation had undertaken to light. He thought it would be evident to all engineers present that there was something wrong when the Glasgow Corporation, having undertaken to light not only the compulsory area (which is really all they had been compelled to consider up to this time), but the whole Royal burgh of Glasgow, already in their first winter, had nine separate engines running in the station. Not only that, but the station, as at present constituted, could not be very much increased in size. The answer to that was that another one would be started, and that it was better not to have too many eggs in one basket. Various other reasons which had a certain amount of cogency were pleaded in excuse. There was a limit to the size of stations, it was true, but there was also a limit to the possibility of starting electrical factories all over a city like Glasgow, and it seemed reasonable to suppose that in lighting a city like Glasgow, they should look to the experience of gas distribution as a guide as to what they might do with electricity. He contended that there should be as many stations for electric lighting as gasworks at present, because the problem was the same. He hoped at next meeting to bring forward some considerations which might interest the institution with regard to some of the points Mr. Arnot had mentioned, especially with respect to the load curves and to the efficiency of the engines. These were very interesting points indeed, and, after all, were the centre of the matter. It would be evident to anyone who looked at those curves that to use steam-engines, or any other source of power, for the production of electric lighting was not an economical thing to do, and all that could be done, as Mr. Arnot had pointed out, was to run the engines at full load for only a very short period of their existence. The rest of the time they were standing idle and doing nothing. That was a kind of industry which was not a paying one, and therefore strenuous efforts had been made to find some means of storing the work of the engines so as to apply it to the circuit when the load curves reached that very high peak which occurred during the greater part of the winter, between 5 and 6 o'clock in the evening. The attempt to do that had been so far unsuccessful. The use of accumulators was indicated in that diagram by the blue lines, and they would see how very small a part they played in the operation of the station. It was totally insignificant as compared with the work done by the engines, and although they were useful in their way, he thought that on the whole the practice adopted in America would be followed in this country, and that batteries would not be used in lighting stations. There were some other points that he would beg respectfully to differ with Prof. Kennedy upon in his arrangement of the switchboard. It seemed to him that his arrangements of the switchboard were very complicated—it seemed to him partly owing to the use of batteries, which led to more complication than was warranted by their use in working. Perhaps Mr. Arnot would be good enough to say what was the maximum loss in the feeders. He mentioned that under certain circumstances it was 25 volts, or 12½ per cent., or thereby. Now that was another matter which meant a considerable amount of complication on the switchboard. If there was a loss of 12½ per cent. between the generating plant and the most distant part of the system, that loss had got to be compensated for in the engine-room, and as the loss varied with the load the compensation would vary, and that necessitated constant watchfulness on the part of the attendant, and was one of the reasons why the continuous system was more difficult to work than the alternating-current system. As to question of the relative cost of high and low tension systems, this was a battle which had yet to be fought out, and had to be won by one side or another. There were many cases where continuous currents had a superiority over alternating currents, but the case in question was, in his opinion, not one of these. The published figures of relative costs of lighting stations were interesting in this way—they proved that the first cost of an installation of continuous currents was greater than the first cost of alternating currents per lamp, but that the cost of working the continuous system was less than that of working the alternate-current system per unit, and in balancing these two it was very difficult indeed for the most ardent partisan of either system to find very much to say on the question of economy, so that the thing resolved itself into a matter of convenience; and, fortunately, nowadays there was plenty of opportunity for gaining the experience that would determine which was the more practically convenient. There was an element in this question which was specially interesting to Clyde engineers. Prof. Biles, in his paper recently read to this institution, pointed out that there was a possible limit to the size and speed of ocean steamers. It therefore might come to be a question whether the Clyde engineers might not take up the construction of large land engines on marine lines. This had already been done to some extent, and it might be interesting to Clyde engineers to know that experience showed that the use of alternating current tended to increase the size of the engines used. The Waterloo-street station was a very good object-lesson on this point. There were already nine engines in this station, producing a total horse-power of something under 2,000, whereas the speaker thought that it was not too much to expect that the lighting of a city like Glasgow would ultimately give employment to engines of such powers as 10,000 horse, rather than the small units now employed.

Prof. Jamieson said he hoped to discuss this paper at next meeting after it had been printed. Mr. Mavor had, however, brought forward a little of the history of this installation, and consequently it might not be out of place to say that he (Prof. Jamieson) was consulted by the Glasgow Corporation Electric Light Committee, and had many meetings with them before Lord Kelvin was called in and approved of the advice which he had given—viz., that under the peculiar circumstances in which they were placed (with a dense but limited compulsory area), and seeing that they had so little time to plan, erect, and equip a central station, they should go in for the safe and sure system which Mr. Arnot had described to them that evening. He did not agree with Mr. Mavor on many points, and especially that part where he said that they should have great big engines working at one big centre. He believed rather in using comparatively small engines, and consequently in being able to put in or take out power as the public demanded the same. He complimented the author for having brought his paper before their society, for the members evidently took a great interest in such matters, and it was likely to bring out a lively and useful discussion.

Mr. Biggart said they were all interested in such a paper as the one now read, but some were more interested from the point of view of that of the consumer than that of the producer, and he thought Mr. Arnot had not given much information with regard to the cost of electrical lighting as compared with that of gas;

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Now, he believed there were many who would be consumers if they could see that the light could be supplied at a moderate rate. He had heard estimates outside of what the cost was as compared with the gas light, and some of these stated the gas was only one-third of the cost of the electrical light. Perhaps Mr. Arnot would be able to confirm or contradict that next evening.

SOLIDS, LIQUIDS, AND GASES.

At the Royal Institution, on Thursday of last week, Prof. Dewar gave the second lecture of his course on the "Solid and Liquid States of Matter." In his previous lecture he dealt with the changes of matter from liquid to gas, from gas to liquid, and from liquid to solid. He explained what was meant by the critical temperature of a liquid, and showed that no substance can be induced to remain in the liquid state if heated above its critical temperature. At the critical point, too, the volume of every liquid is at its maximum, while it is a minimum just when passing into the solid state, and the ratio between these two volumes is almost the same for all liquids—viz., 3 to 1. The transition from gas to liquid was illustrated by liquefying carbonic acid gas under pressure To make a substance pass from liquid to solid it is necessary to make it part with some of its heat. Solidification in some cases may be produced by rapidly evaporating the liquid under the air-pump, and in others by the application of great pressure. In general the heat must be increased if a substance is to remain liquid under pressure. Ice, however, melts under pressure, and by this fact the phenomenon of regelation can be explained. In his second lecture Prof. Dewar used ice to illustrate the changes which may be caused by pressure in the physical properties of substances. At ordinary pressure ice is a brittle substance, but under a pressure of 30 or 40 tons to the square inch it behaves like a viscous solid and may be forced through a narrow orifice in the form of a fine wire If, however, it were cooled to 20deg. below zero, an immensely greater pressure would be required to make it act in the same way. After describing his now well-known vacuum jackets, by the aid of which he can keep liquefied gases for many hours, the lecturer proceeded successively to liquefy and solidify common air in the presence of the audience. An empty test-tube open to the air was placed in liquid oxygen contained in a vacuum jacket. When the oxygen was evaporated under the air-pump, liquid air condensed in the inner tube. This tube was then also put under the air-pump, and in a few seconds the liquid air in it became solid, at a temperature of about 210deg. C. below zero—the lowest temperature yet reached. Some illustrations of the effects of extreme cold on bodies was then given. Several of the salts of mercury, such as the iodide and red oxide, which are red at ordinary temperatures, became yellow when cooled to −180deg., showing that the conditions of the absorption of light are greatly modified at low temperatures. At −180deg. only one compound gas refuses to solidify, and that is carbonic oxide, the most volatile compound known. At this temperature some substances freeze into a glassy ice, others into an opaque crystalline solid. Methyl alcohol or wood spirit and bisulphide of carbon are examples of the latter class, amyl alcohol, the chief constituent of potato spirit, and turpentine of the former. The vapour given off by liquid oxygen boiling at −180deg. is at that temperature, and is about three times as dense as ordinary air. In it very fragile bodies can be cooled, and the pretty experiment was shown of freezing a soap bubble in it. Extreme cold has a curious effect on indiarubber, which, when under tension, contracts on heating and expands on being cooled. In conclusion, the lecturer showed how to measure the quantity of heat taken in by a liquid on expanding. This is effected by introducing a known amount of heat (as can be done by dropping in a certain quantity of mercury) and measuring how much gas is distilled off. By a slight modification of the method the specific heat of the liquid may be calculated.

COLOUR VISION.

Captain Abney, F.R.S., gave his second lecture on colour vision at the Royal Institution on Saturday afternoon. He began by showing diagrams in explanation of the Young-Helmholtz theory of colour perception, which is the one perhaps most generally accepted at the present time. It supposes that for the normal eye there are three fundamental sensations—red, green, and violet. Any colour—except, perhaps, those at the very extremities of the spectrum—excites all these sensations, but in different degrees, the colour green, for instance, especially exciting the sensation green, though it also to some extent excites the red and violet sensations. White is the effect of the equal stimulation of the sensations. This theory Captain Abney considers is capable of explaining all cases of colour-blindness that are congenital and not the result of disease. About 5 per cent. of mankind are colour-blind—that is, are deficient in their perception of one of the fundamental sensations, most commonly red. Persons have been found, too, who are wanting in two of the sensations, and, therefore, have monochromatic vision. In such cases it is usually the violet sensation that remains, but Captain Abney has found one person who sees all things green, and would much like to meet one who sees only red. With a very small illumination—say, 1-100 of a candle-power, everyone has monochromatic vision, and this fact explains why colours are seen so badly by moonlight, which is a very feeble light. Besides being unable to perceive certain colours the colour-blind man is incapable of accurately estimating the brightnesses of colours. Thus, a man who is blind to red will affirm that a certain patch of white is as bright as a given patch of red, though to the normal eye it is manifestly less bright. Captain Abney concluded by showing that the eye is not equally sensitive to the different colour sensations. Thus, if the illumination of two patches of colour, the one dull green and the other bright red, be gradually diminished, the green will be visible for some time after the red has disappeared.

CANADA IN RELATION TO THE UNITY OF THE EMPIRE.

There was a large attendance at the ordinary monthly meeting of the Fellows of the Royal Colonial Institute at the Whitehall Rooms, Hôtel Métropole, on May 8, to hear the Canadian High Commissioner's interesting address on the above subject. The Marquis of Lorne occupied the chair.

Sir CHARLES TUPPER began his address by saying that the most important event of recent years conducive to the unity of the British Empire was the confederation of Canada. Another important event pointing in the same direction was now impending. A conference of representatives of the Governments of Australasia, of the Imperial Government, and possibly of the South African Governments, would be held at Ottawa in June for the purpose of considering the best means of drawing these great outlying possessions of the Crown into closer trade relations with each other and with Great Britain. A deputation of the representatives of Australasia, South Africa, and Canada recently had an interview with the Earl of Rosebery and the Marquis of Ripon on this subject. They stated that Canada had agreed to give a subsidy of £175,000 a year to a fast steamship service between England and Australasia *vid* Canada, and would give substantial support to a cable from Vancouver to Australia, and that these subsidies would be largely supplemented by the Governments of Australasia, and they asked for the co-operation and aid of her Majesty's Government to these services on the ground of their great political, strategical, commercial, and defensive value. This movement had received, as might naturally be expected, the hearty support of a large portion of the Press of this country. Many persons had been surprised to find that Sir John Colomb, who had professed to be a friend of the unity of the empire, had assumed a position of hostility to these proposals. He was apparently not well informed of the extent to which the great colonies had rendered yeoman service to the defence of the empire—unless, as he seemed to think, the term empire applied only to Great Britain. Who, with such evidence as the trade returns before them, could question from an Imperial standpoint the importance of developing the commerce between the colonies and between them and the mother country? The present intention of the proposed steamship company was to have upon the Atlantic a weekly service of 20-knot speed all the year round, and to maintain it by the building of four exceptionally large, swift, completely equipped, express passenger steamships. On the Pacific, at present, it was only proposed to have three steamships, thus adding one steamship to those now performing the monthly service between Sydney and Vancouver. At the Ottawa Conference one of the most important subjects for consideration would be whether the time had arrived for Great Britain and the Australasian Colonies to recognise Canada as an Imperial highway for an Australasian mail service, affording the empire an important alternative route; and he ventured to hope that a favourable decision would be arrived at. Sir John Colomb had asked who was to pay and to be responsible for the protection in war of the new trade line and new submarine cable we were asked to help to establish? There was the highest authority for the opinion that the naval strength provided by these fast steamers on the Atlantic and Pacific Oceans and the proposed cable from Vancouver to Australia formed the strongest claims to Imperial support. The contract entered into by the Government of Canada with Mr. James Huddart required the four Atlantic steamships to be capable of steaming 20 knots, under favourable conditions, at sea, and this would involve a trial trip speed of 21 knots, or equal to 24 statute

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miles per hour. The steamships would be upwards of 10,000 tons register, and would be built in compliance with the usual conditions necessary to secure the subvention for mercantile armed cruisers from the British Admiralty. The Colonial Conference called and presided over by the Secretary of State for the Colonies in 1887 passed a resolution that the connection of Canada with Australia by direct submarine telegraph across the Pacific was a project of high importance to the empire. Of course those who had long enjoyed a monopoly might be expected to oppose competition, and he was not surprised at the protest made by those interested parties to her Majesty's Goverment. The cable companies which controlled the existing lines between the United Kingdom and Australasia "urged that the existing service was established solely by private enterprise," and without Government aid. These lines, however, had the advantage of being the first lines established, and thus had no opposition to contend with. The Pacific cable would, however, now have to compete with these very existing lines, which, whatever the case might have been when they were initiated, were now, and for many years past had been, assisted by annual subsidies. Altogether, the existing companies which would compete directly or indirectly with the Pacific cable had received in subsidies from various sources up to the present time more than £2,100,000, an amount much in excess of the capital required for a Pacific cable. He calculated that a total traffic of £96,250 might reasonably be looked for in the first year's working of the new cable. The protest against the cable was largely based upon fallacies. If the reasons urged by those who had so long enjoyed a monopoly should result in her Majesty's Government not giving the assistance required, the competition dreaded would not be prevented, but transferred to a company under the control of a foreign power, and England would have lost its opportunity. Australasia and Canada made no "demand" upon the taxpayers of this country, but, on the contrary, proposed to unite with the Imperial Government in providing an alternative line of steam and cable communication between England and Australasia and Canada, uniting those great possessions of the Crown more closely to each other and to the mother country, and furnishing in the best manner possible the means of expanding the trade and strengthening the unity and defence of the empire.

The discussion was opened by Sir JOHN COLOMB, who congratulated Sir Charles upon his address, and assured him that he had not taken up a hostile attitude to the Pacific cable and steamship services. Australasia and Canada were two portions of the empire which desired, and rightly desired, to come closer together. They wanted a mail route and a cable, and they asked the people of the United Kingdom to find a considerable portion of the money. They rested their claim on the ground that these things would contribute to the safety of the empire in case of war. As a cable or sea line could not protect itself, who was to protect it in such a case? He was not really opposed to these schemes, but merely asked who was to pay for the defence of the line. Canada paid less for naval and military defence than she ought to pay.

Mr. R. R. DOBELL, of Quebec, spoke next, and in the course of his observations said that Sir Charles Tupper's address would tend very much to strengthen the bonds already existing between the colonies and the mother country. He believed we were reaching a more intelligent conception of the grand scheme of Imperial federation, and, going back as he was to Canada in a few days, he should be able to carry back with him a very hopeful feeling that the people of this country were paying greater attention to their colonies.

The Hon. DUNCAN GILLIES (Agent-General for Victoria) warmly supported the proposal, and said that the colonies did not ask anything unreasonable in the matter from the Imperial Government. The Pacific steam route and cable were eminently desirable in the interests of the whole empire. As to who would protect the cable, he took it that England would never allow even the existing cable, which belonged to a company, to be interfered with, and he took it that, as a matter of honour, the Imperial Government would look after this cable, should it be laid. If the conference that was to be shortly held at Ottawa came to a conclusion in favour of the proposals, he was perfectly sure that the colonies would not be behindhand in their contributions.

Sir LAMBERT DOBSON (Chief Justice of Tasmania) said that the question resolved itself into one of whether the propositions put forth by the High Commissioner for Canada were beneficial to the empire. He had no hesitation in saying that the proposed line of communication would be valuable both to the mother country and the colonies, and if they agreed that the thing was good in itself, let them not be frightened by a possibility of what might occur in the event of war.

Sir GEORGE S. CLARKE followed, and warmly supported the propositions made by Sir Charles Tupper.

Mr. G. R. PARKIN, M.A., observed that the question Sir John Colomb had asked would have to be answered some day so far as the navy was concerned; but the time was not now ripe, and the tone in which it was asked was not a politic one. So far as military defence was concerned, remembering 1812, when 300,000 Canadians were more than a match for 3,000,000 invaders, he should say that Canada could take care of herself in any event. The Imperial interest in these cable and steamship lines was paramount.

The Hon. RICHARD O'CONNOR, M.L.C., of Sydney, and the Rev. Dr. LUCAS, of Canada, also spoke.

Lord LORNE having summed up the discussion, a vote of thanks to Sir Charles Tupper was unanimously adopted. A hearty vote of thanks was also given to the Marquis of Lorne for presiding, and the meeting terminated at rather a late hour.

Sir John Pender has addressed the following letter to Sir Charles Tupper:

"Winchester House, London, E.C., May 15, 1894.

"Dear Sir Charles Tupper,—I have carefully looked through the paper which you read last week at the meeting of the Royal Colonial Institute, and had I been well enough to attend the meeting I should have made an effort to be present.

"I cannot, however, allow your statement to pass unchallenged that the 'protest against the proposed cable is largely based upon fallacies,' feeling convinced that if you would carefully study our figures and arguments, which are based on actual facts and practical experience of cable working, and compare them with those furnished by Mr. Sandford Fleming, you would come to the conclusion that the fallacies are not on our side, but on your own.

"For instance, to take the first point in your paper relating to amortisation, you are entirely mistaken in stating that 'some 5,350 miles (or about 30 per cent.) of the 18,000 miles of cable now forming the system of the Eastern Extension Telegraph Company is more than 20 years old, and is still in working condition, the balance of about 12,650 miles being duplications and extensions laid since 1874.' As a matter of fact, nearly the whole of the cables orginally laid by the Eastern Extension Company have been renewed, some entirely, and in a considerable shorter period than 20 years.

"Then, as to your estimate of traffic for a Pacific cable, you have quite ignored the fact that at the Wellington Conference it was decided that the ordinary tariff should be 3s. per word, instead of 3s. 3d. as proposed by Mr. Sandford Fleming; consequently, after the necessary outpayments are deducted, which would probably amount to 1s. 6d. (1s. for the Atlantic cables and 6d. for the Canadian and Australian land lines), there would be only 1s. 6d. left for the Pacific cable instead of the 2s. relied upon by Mr. Sandford Fleming, and this discrepancy materially affects your figures.

"Moreover, any calculations based upon such an unknown quantity as the 'normal increase of traffic' cannot be at all reliable, as the circumstances are constantly changing. For example, the growth of traffic with Australasia during the year ending April 30, 1892, was only 8·34 per cent. over that of the previous year, and in the following year, ending April, 1893, it was less than 6 per cent., as compared with 1892, showing that Mr.

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Sandford Fleming's estimate of a minimum 12½ per cent. is quite misleading.

"It is equally unsafe to rely too closely on calculations of increase resulting from reductions of tariff, experience having unfortunately shown that on more than one occasion a falling off of traffic has actually taken place after a substantial lowering of rates, instead of a considerable increase such as your paper indicates would result if the Australian tariff were reduced from 4s. 9d. to 3s. 3d. per word.

"Then, again, your description of the existing system as a 'monopoly' cannot be justified, seeing that it has never received any exclusive landing rights from the Australian Governments, but has had to rely upon the business-like and economical principles upon which it has been established and worked for its freedom from competition. In fact, the field has always been open to all comers to compete with us, and upon equal terms I should have nothing to say against it, but supported by Government aid it would be quite another matter, and if a Pacific cable were established on this basis and the pioneer company, which has done so much for the Australasian colonies in providing them with perhaps the best submarine service in the world, were ignored, it would certainly be disastrous to private enterprise, and the Governments interested could not in common fairness adopt such a course without granting similar pecuniary assistance to the existing system.

"No doubt a single cable could be constructed and laid for £1,800,000, and it would undoubtedly materially benefit the cable manufacturers, but no company who knew anything about the business and would be held responsible for carrying it through could undertake the work with any prospect of making it pay on the terms of the Wellington Conference resolution.

"At the present moment, however, the proposed cable is not really needed for commercial purposes, and therefore the expenditure of nearly two millions sterling, when neither the Imperial nor Colonial Governments can well afford it, would, in my opinion, be an unwarrantable waste of money.

"If, however, the Governments concerned consider a second cable is required for strategic purposes, which I very much doubt, they must, of course, pay for it, and, as I have frequently stated, my company would be quite prepared to undertake the work on fair and reasonable terms, which terms would necessarily be more favourable to the Governments than could be obtained from any other company, owing to the exceptional facilities possessed by the existing system.

"The probability of opposition arising from foreign sources does not in the least alarm me, but should competition be brought about through English and colonial agencies on the proposed terms the result must inevitably be that no dividend would be forthcoming for the new company, and little, if any, for the pioneer service.

"I have thought it only fair to yourself as well as to the companies which I represent that you should be placed in possession of the above information, as you will doubtless be making further reference to the Pacific cable movement, and, with so much attention now being paid to all public utterances on the subject, it is of the greatest importance that all figures bearing on the question should be as accurately stated as possible.

"I am sending a copy of this letter to the *Times*.

"Yours faithfully,

"JOHN PENDER.

"Sir Charles Tupper, Bart, G.C.M.G., C.B., etc."

TELEGRAPHS AND TRADE ROUTES IN PERSIA.*

BY LIEUT.-COLONEL HENRY L. WELLS, R.E.

The interest taken in the paper on "Telegraphic Communication between England and India," which was read to this society in February last, led to my being asked to give an account of the Indo-European telegraphs in Persia, and of the local telegraphs in that country from the time that I became acquainted with their administration—viz., January 1881; and secondly, to bring the history of the trade routes in Persia up to date, a subject which has attracted much attention on the part of my predecessors, as evinced by papers read thereon by three successive directors of telegraphs. The Indo-European Telegraph Company comes from London *vid* Lowestoft, Emden, Berlin, Warsaw, Odessa, Kertch, Sukumkaleh, Tiflis, and enters Persia at the passage of the River Araxes, which forms the frontier between that country and Russia. Since 1880 a great improvement has been effected in the working of their line, by carrying two of the wires on bare porcelain insulators, supported at either end of an oaken arm, which is attached to the iron standards of the Siemens pattern. This system of insulation is the very best yet devised for long-distance land lines in Central Asia. The third wire is still carried as formerly on a Siemens iron hooded insulator, which is attached underneath the oaken arm above referred to, and is for the use of the Persian Government. The companies' lines are well constructed and admirably maintained. The Persian portion of their system traverses a very elevated plateau; for instance, at Zenjan, the whole surface of the country has an elevation varying from 5,000ft. to 6,000ft. above the sea. The distance from Djulfa, where the line crosses the Araxes, to Teheran is 440 miles. The line runs parallel to the main mountain chains, which protect it from the north winds. Throughout the above-mentioned distance, the altitude of the country passed over by the line does not vary more than 3,000ft. This fact, together with that of its being protected by the mountain ranges, accounts for the singular immunity from interruptions it enjoys.

Since I was placed in charge of the construction branch of the lines in 1881, the whole length has been bit by bit overhauled, the supports being in many instances placed closer together, and the direction of the line changed where experience showed such change advisable. The result has been a vast improvement, as shown by the wonderful immunity from interruption the line now enjoys. The system of insulation, moreover, has been improved, and all three wires are now carried on porcelain insulators, supported on malleable iron brackets, which are bolted round the Siemens standards. The third wire is here also for the use of the Persian Government. At Teheran, the capital, the Indo-European Company's administration terminates, and that of the Government commences. The Indo-European line runs south from Teheran to Kom, skirting the great desert on its western extremity. The distance by this route from Teheran to Kom was 84 miles. From Kom the line skirts the desert to Kashan and passes through villages which used to be liable to be pillaged by Turcomans. The altitude of Kom is 3,100ft. From Kashan, which has an altitude of 3,200ft., the line following the shortest route to the south rises 5,500ft. in 32 miles to the summit of the Kohrud Pass, which has an altitude of 8,750ft. This is a difficult piece of line to keep free from interruption during winter, and it took several years to find the best direction for the wires, and overcome the difficulties due to the intricacies of the rock-bound defiles, and the sudden gusts of snow-laden wind that rush through them. The third sub-section extends from Meshad-i-Moorgab to Mian-Kotul, a distance of 131 miles. The fourth section extends from Mian-Kotul to the sea, and is the only one which is below the winter snow line—distance 102 miles. The total length of line is 675 miles.

Gradually, by substituting poles of cypress wood—which white ants do not touch—for those of poplar, by cutting out the bad wire and making good joints, fitting up the offices, and renewing the instruments, and, by transferring the utterly worthless members of the staff, the period of interruption has been reduced from 1,600 hours in 1887 to 543 in 1893. The system of dual control, which is now producing results with which H.I.M. the Shah expresses himself highly pleased, is feasible, thanks to the large-mindedness and liberal spirit of his Excellency the Mukhber-ed-Dowleh. The line suffers most severely from camels. These animals, when casting their coats in the autumn, go for the telegraph line. Nothing but iron standards, with spreading foot-plates, will overcome this difficulty. If this line is to be kept up, and in the future prolonged through Herat and Candahar to the British frontier at Chaman, it must be entirely reconstructed with Siemens iron standards ere it can be considered an efficient or thoroughly reliable means of communication.

* Abstract of paper read before the Society of Arts.

ELECTRICITY IN MINING OPERATIONS.

A number of pumping, haulage, and lighting contracts at various collieries, in addition to a number of mills, factories, shops, and complete plants for country residences, has recently been carried out by Messrs. John Davis and Son, of Derby.

In the case of the combined lighting and haulage plant erected by that firm for the West Hallam Colliery Company, near Derby, the dynamo is compound wound, of 50 h.p., and is driven by an endless belt from a pair of horizontal engines. This machine supplies current for lighting the offices, shops, pit banks, yards, etc., on the surface with incandescent and arc lamps, the main roads underground with incandescent lamps protected by special damp and dust proof fittings, and also for a 10-h.p. motor employed for haulage. Since the motor was started, not a single ton of coal has been lost, and, moreover, this one machine has displaced 14 horses in the pit, besides dealing with a much larger quantity of coal than previously. This plant is now being extended to a 20-b.h.p. combined pumping and haulage plant, for hauling by day and pumping by night, and a separate 10-h.p. motor and pump for dip pumping. Another colliery pumping plant recently installed for the Ackton Hall Colliery Company, near Pontefract, consists of a 25-h.p. motor and pump forcing 12,000 gallons per hour up a vertical height of 240ft.; the cables are of the concentric type insulated with vulcanised indiarubber and carried down the shaft in wrought-iron pipes as an extra precaution

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against mechanical injury. Another small pump and motor to force 360 gallons per hour up a vertical height of 1,200ft. is also at work.

Messrs. John Davis and Son are putting down electric motors provided with their safety commutators at long distances from the pit bottom in districts in which the use of locked safety lamps is imperative. A combined lighting and pumping plant, with the motor constructed under the firm's patent, has been erected for the Clay Cross Company at their Morton Colliery. The lighting consists of lamps varying from 16 c.p to 150 c.p. on the surface, and underground. in addition to a number of lamps, there is laid down a 3-h.p. safety commutator or motor driving a three-throw pump forcing 600 gallons per hour up a vertical height of 128ft. through 2,400ft. of 2in. pipes. The motor and pump are situated one mile from the dynamo, and are now doing in one quarter of the time three times the work originally done by horses. Another pumping plant, with spare power for lighting, has just been erected for the Wingerworth Colliery Company, near Chesterfield, for clearing the flooded workings. It is situated one mile from the dynamo, and is forcing 1.200 gallons per hour up a vertical height of 150ft. through 2,400ft. of 7in. pipe. In order to deal with the water quicker, a duplicate plant is now being constructed to deliver its water on the surface. As a type of export plant we may mention that supplied by Messrs. John Davis and Son to the St. John Del Rey Mining Company, for lighting their stamp mills, shops, yards, engine-houses, mines, and managers' residences with arc and incandescent lamps. The plant consists of a compound-wound dynamo specially constructed for transport driven by a Pelton waterwheel, switchboard with regulating and controlling switches, measuring instruments, lamps, brackets, fittings, etc., complete. The dynamo is situated one mile from the nearest lamps; the pressure is, however, kept constant at all loads by means of a special arrangement of connections. These are only a few of the most recent plants erected by the firm, the list of work executed during the last 12 months containing, amongst others, the Lea lead-works of Messrs. Wass and Sons, and a number of collieries and works.

THE NATIONAL ELECTRIC LIGHT ASSOCIATION'S STANDARD RULES FOR ELECTRICAL CONSTRUCTION AND OPERATION.

(Concluded from page 443.)

CENTRAL STATIONS.

CLASS C.—OVERHEAD CONDUCTORS—INCANDESCENT (LOW PRESSURE) SYSTEMS (300 volts or less).

Outside Overhead Conductors.

1. Must be erected in accordance with general rules for arc (series) circuit conductors.
2. Must be separated not less than 6in. where they enter buildings as service conductors, and be provided with a double-pole fusible cut-out, as near as possible to the point of entrance to the building, and outside the walls when practicable.

Underground Conductors.

1. Must be provided with suitable protecting devices at the ends of tube or conduit services inside the walls of buildings, as a guard against moisture and injury.
2. Must be terminated at a properly placed double-pole house cut-out.
3. Must be of specially insulated conductors after leaving the tube or conduit, and separated by at least 10in., until the double-pole cut-out is reached.

Inside Wiring.

1. Where practicable wire, should be so placed that in the event of the failure or deterioration of their insulating covering the conductors under this condition will still remain insulated.
2. At the entrance of every building there shall be a double-pole switch placed in the service conductors, whereby the current may be entirely cut off.

Conductors.

1. Must not be of sizes smaller than No. 16 B. & S., No. 18 B.W.G., or No. 3 E.S.G.
2. Must not be paraffin covered.
3. Must not be covered with soft rubber tube.
4. Must not be laid in mouldings of any kind in damp places.
5. Must not be laid in mouldings with open grooves against the wall or ceiling.
6. Must not be laid in mouldings where less than ¼in. of solid insulation is between parallel wire, and between wires and walls or ceilings.
7. Must not be laid in plaster, cement, or similar finish, without an exterior metallic protection.
8. Mouldings, where admissible, must have at least two coatings of waterproof paint, to be impregnated with a moisture repellent.

Cleatwork.

1. Cleatwork is not desirable, and cleats must not be used unless in a very dry place.
2. Must not be used unless in a place perfectly open for inspection at any time.
3. Must not be used unless they are of porcelain, or well-seasoned wood, filled, to prevent absorption of moisture.
4. Must not be used unless they are so arranged that wires of opposite polarity, with a difference of potential of 150 volts, or less, will be kept at least 2½in. apart, and that where a higher voltage is used this distance be increased proportionately.
5. Must not be used unless there is a backing provided of wood at least ½in. thick, well seasoned and filled to prevent absorption of moisture.

Metal Staples.

1. Metal staples must never be used to fasten conductors unless provided with an insulating sleeve or saddle rigidly attached to the metal of the staple, and having such strength and surface as to prevent mechanical injury to the insulation of the conductor.
2. Must never be used to fasten conductors unless under conditions in which cleatwork would be acceptable, or where driven into a moulding specially adapted for open work.

Special Wiring.

1. Whenever conductors cross gas, water, or other metallic pipes, or any other conductors or conducting materials (except arc light wires), they should be separated therefrom by some continuous non-conductor at least 1in. In crossing arc light wires the low-tension conductors must be placed at a distance of at least 6in. In wet places an air space must be left between conductors and pipes in crossing, and the former must be run in such a way that they cannot come in contact with the pipe accidentally. Wires should be run over all pipes upon which condensed moisture is likely to gather, or which by leakage might cause trouble on a circuit.
2. In rooms where inflammable gases may exist, or where the atmosphere is damp, the incandescent lamp and socket should be enclosed in a vapour-tight globe. This is not to be understood to include rooms where illuminating gases are used in the ordinary manner.
3. In breweries, stables, dye-houses, paper and pulp mills, or other buildings specially liable to moisture, all conductors, except where used for pendants:
4. Must be separated at least 6in.
5. Must be provided with a durable moisture-proof covering.
6. Must be carefully put up.
7. Must be supported by porcelain or glass insulators.
8. Moisture-proof and non-inflammable tubing may be accepted in lieu of such construction.
9. No switches or fusible cut-outs will be allowed in such places.

Interior Conduits.

1. Must not be combustible.
2. Must not be of such material or construction that will be injured by plaster, cement, or other surrounding material, or that the insulation of the conductor will ultimately be injured or destroyed by the elements of its composition.
3. Must not be so constructed or placed that difficulty will be experienced in removing or replacing the conductors.
4. Must be continuous from one junction-box to another or to fixtures, and of non-inflammable material, and of a substantial character, as in the case of the existing gas and water pipes, in order to afford mechanical protection from injury by saws, chisels, or nails.
5. Whenever practicable, pipes for all purposes must be kept from the conduits or wire-ways, and under no circumstances must steam-pipes be placed therein.
6. Architects and builders should provide suitable wire-ways or openings in all buildings at the time of their construction, in which could be placed electric wires and conduits according to the requirements of the building.
7. Prior to the insulation of the wires, powdered soapstone should be blown through the conduit tubes to facilitate the drawing in of the same.
8. Must not be depended upon for insulation. The conductors should be covered with moisture-proof material.
9. The object of a tube or conduit is to facilitate the insertion or extraction of the conductors, to protect them from mechanical injury and, as far as possible, from moisture.
10. Conductors passing through walls or ceilings must be encased in a suitable tubing, which must extend at least 1in. beyond the finished surface until the mortar, or other similar material, be entirely dry, when the projection may be reduced to ½in.

Double-Pole Safety Cut-Outs.

1. Must be placed where the overhead or underground conductors enter a building and join the inside wires.
2. Must be placed at every point where a change is made in the size of the wire (unless the cut-out in the larger wire will protect the smaller). This includes all flexible conductors. All such junctions must be in plain sight.
3. Must be constructed with bases of non-combustible and moisture-proof material.
4. Must be so constructed and placed that an arc cannot be maintained between the terminals by the fusing of the metal.
5. Must be so placed that on any combination fixture no group of lamps requiring a current of six amperes or more shall be ultimately dependent upon one cut-out.
6. Must be, wherever used for more than six amperes, or (where the plug or equivalent device is not used) equipped with fusible strips or wires, provided with contact surfaces or tips of harder metal, soldered or otherwise, having perfect electrical connection with the fusible part of the strip.

Safety Fuses.

1. Safety fuses must be so proportioned to the conductors they are intended to protect that they will melt before the maximum safe carrying capacity of the wire is exceeded.
2. All fuses, where possible, must be stamped, or otherwise marked, with the number of amperes equal to the safe carrying capacity of the wire they protect.

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3. All cut-out blocks when installed must be similarly marked.

4. The safe carrying capacity of a wire changes under different circumstances, being about 40 per cent. less when the wire is closed in a tube or piece of moulding than when bare and exposed to the air, when the heat is rapidly radiated. It must be clearly understood that the size of the fuse depends upon the size of the smallest conductor it protects, and not upon the amount of current to be used on the circuit. Below is a table showing the safe carrying capacity of conductors of different sizes in Birmingham, Brown and Sharpe, and Edison gauges, which must be followed in the placing of interior conductors.

Brown & Sharp.		Birmingham.		Edison Standard.	
Gauge No.	Amperes.	Gauge No.	Amperes.	Gauge No.	Amperes.
0000	175	0000	175	200	175
000	145	000	150	180	160
00	120	00	130	140	135
0	100	0	110	110	110
1	95	1	95	90	95
2	70	2	85	80	85
3	60	3	75	65	75
4	50	4	65	55	65
5	45	5	60	50	60
6	35	6	50	40	50
7	30	7	45	30	40
8	25	8	35	25	35
10	20	10	30	20	30
12	15	12	20	12	20
14	10	14	15	8	15
16	5	16	10	5	10
—	—	18	5	3	5

Switches.

1. Must be mounted on moisture-proof and incombustible bases, such as slate or porcelain.

2. Must be double pole when the circuits which they control are connected to the fixtures attached to gas-pipes, and when six amperes or more are to pass through them.

3. Must have a firm and secure contact, must make and break readily, and not stick when motion has once been imparted by the handle.

4. Must have carrying capacity sufficient to prevent heating above the surrounding atmosphere.

5. Must be placed in dry accessible places, and be grouped, as far as possible, being mounted, when practicable, upon slate or equally indestructible back-boards.

Motors.

1. In wiring for motive power, the same precautions must be taken as with the current of the same volume and potential for lighting. The motor and resistance-box must be protected by a double-pole cut-out, and controlled by a double-pole switch.

Arc Lights on Low-Potential Circuits.

1. Must be supplied by branch conductors, not smaller than No. 12 B. & S. gauge.

2. Must be connected with main conductors only through double-pole cut-outs.

3. Must be furnished only with such resistances or regulators as are enclosed in non-combustible material, such resistances being treated as sources of heat.

4. Must be supplied with globes protected as in the cases of arc lights on high-potential circuits.

Fixture Work.

1. In all cases where conductors are concealed within, or attached to, fixtures, the latter must be insulated from the gas-pipe system of the building by an insulating joint, the material of which shall not be affected by gas or changes of temperature.

2. When wired outside, the conductors must be so secured as not to be cut or abraded by the pressure of the fastenings or motion of the fixtures.

3. All conductors for fixture work must have waterproof insulation that is durable and not easily abraded, and must not in any case be smaller than No. 16 B. & S., No. 18 B.W.G., or No. 3 E.S.G.

4. All burrs or fins must be removed before the conductors are drawn into a fixture.

5. The tendency to condensation within the pipes must be guarded against by sealing the upper end of the fixture.

6. No combination fixture in which the conductors are concealed in a space less than ¼in. between the inside pipe and the outside casing will be approved.

7. Each fixture must be tested for possible "contacts" between conductors and fixture, and for "short-circuits," before the fixture is connected to its supply conductors.

8. The ceiling blocks of fixtures should be made of insulating material.

Electric Gas Lighting.

Where electric gas lighting is to be used on the same fixture with the electric light:

1. No part of the gas-piping or fixture shall be in electrical connection with the gas lighting circuit.

2. The wires used with the fixture must have a non-inflammable insulation, or, where concealed between the pipe and shell of the fixture, the insulation must be such as is required for fixture wiring for the electric light.

3. The whole insulation must test free from "grounds."

4. The two installations must test perfectly free of connection with each other.

Pendants and Sockets.

1. No portion of the lamp socket exposed to contact with outside objects must be allowed to come into electrical contact with either of the conductors.

Cord Pendants.

1. Must be made of conductors, each of which is composed of several strands insulated from the other conductor by a mechanical separator of carbonisable material, and both surrounded in damp places with a moisture-proof and a non-inflammable layer.

2. Must be protected by insulating bushings where the cord enters the socket.

3. Must be so suspended that the entire weight of the socket and lamp will be borne by knots above the point where the cord comes through the ceiling block or rosette, in order that the strain may be taken from the joints and binding screws. All sockets used for wire or cord pendants should have openings at least equal to ¼in. gas-pipe size.

4. Must be allowed to sustain nothing heavier than a four-light cluster, and in such a case special provision should be made by an extra heavy cord or wire, as a mechanical reinforcement.

5. Must be equipped with keyless sockets, as far as practicable, controlled by wall switches. In no case may a lamp giving more than 50 c.p. be placed in a key socket on a flexible pendant.

Electric Heating and Cooking.

1. In general the same precautions should be taken in the installation and operation of electric heating and cooking appliances as are applicable to circuits for electric light and power.

2. The practice of attaching heating and cooking appliances to lamp-sockets must not be permitted where said appliances require over three amperes. Proper circuits must be provided, fully protected by double-pole safety fuses and switches, and the appliances themselves should be kept from contact with inflammable materials.

3. Flexible cords should be used with strands separately covered with non-inflammable insulation, and both wires or strands covered with a water-proofing, and that by a braiding, and especial care should be taken to make proper connections on all appliances, and each should be plainly marked with the maximum volts and amperes they will safely carry.

CLASS D.—ALTERNATING SYSTEMS.

Converters or Transformers.

Converters.

1. Must not be placed inside of any building, except the central station, unless as hereinafter provided.

2. Must not be placed in any but metallic or non-combustible cases, which cases should be connected to earth when wires are underground.

3. Must not be attached to the outside walls of buildings unless separated therefrom by substantial insulating supports.

4. Must not be placed in any other than a dry and convenient location (which can be secured from opening into the interior of the building, such as a vault), when an underground service is used.

5. Must not be placed without safety fuses at the junction between main and service conductors, and safety fuses in the secondary circuits where they will not be affected by the heat of the converter.

Primary Conductors.

In those cases where it may not be possible to exclude the transformers and primary wires entirely from the building, the following precautions must be strictly observed:

1. The transformer must be located at a point as near as possible to that at which the primary wires enter the building.

2. The primary lead of a transformer should be heavily insulated with the highest-class insulation—such as vulcanised pure indiarubber of the best quality, preferably covered with a high-class outer covering, and such leads should have a minimum length of 18in.

3. Between these points the conductors must be heavily insulated with a coating of moisture-proof material, and, in addition, must be so covered and protected that mechanical injury to them or contact with them shall be practically impossible.

4. The primary conductors, if within a building, must be furnished with a double-pole switch, and also with a double-pole cut-out where the wires enter the building, or where they leave the main line on the pole or in the conduit. These switches should, if possible, be enclosed in secure and fireproof boxes outside the building.

5. The primary conductors, when inside a building, must be kept apart at least 10in., and at the same distance from all other conducting bodies.

Secondary Conductors.

1. The conductors from the secondary coil of the transformer to the lamps, or other translating devices, must be installed according to the rules for "inside wiring" for "Low-Potential Systems."

2. Section 1 under primary conductors and referring to primary leads, applies with equal force to the secondary leads.

CLASS E.—ELECTRIC RAILWAYS.

Power Stations.

1. All rules pertaining to arc light wires and stations shall apply (so far as practicable) to street railway power stations and their conductors.

Railway Systems with Ground Return.

Electric railway systems in which the motor cars are driven by a current from a single wire, with ground or floor return circuit, are prohibited, except as hereinafter provided.

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1. When there is no liability of other conductors coming in contact with the trolley wire.

2. When the location of the generator is such that the ground circuit will not create a fire hazard to the property.

3. When an approved automatic circuit breaker, or other device that will immediately cut off the current in case the trolley wires become grounded, is introduced in each circuit as it leaves the power station. This device must be mounted on a fireproof base, and be in full view of the attendant.

Trolley Wires.

1. Must be no smaller than No. 0 B. & S. copper, or No. 4 B. & S. silicon bronze, and must readily stand the strain put upon them when in use.

2. Must be well insulated from their supports, and in case of the side or double-pole construction, the supports shall also be insulated from the poles immediately outside the trolley wire.

3. Must be capable of being disconnected at the power-house, or of being divided into sections, so that, in case of fire on the railway route, the current may be shut off from the particular section and not interfere with the work of the firemen in extinguishing the flames. This rule also applies to feeders.

4. Must be safely protected against contact with all other conductors.

Car Wiring.

1. All wires in cars must be run out of reach of the passengers, and shall be insulated with a waterproof insulation.

Lighting and Railway Power Wires.

1. Lighting and power wires must not be permitted in the same circuit with trolley wires with a ground return, except in street railway cars, car-houses, and power stations. The same dynamo may be used for both purposes, provided the connection from the dynamo for each circuit shall be a double-pole switch, so arranged that only one of the circuits can be in use at the same time.

2. The lines of any electric railroad system employing a ground return must under no circumstance be taken into any building for light, power, or other purposes, save in the house of the power and car houses of the company.

3. Where light or power is supplied from the railway circuits employing a ground return for use in the power-house or car-house of the company, only the highest class of approved insulated wire must be used, the same to be supported on insulators and readily accessible at all times. Inflammable moulding or casing concealing the wires must not be used.

4. Switches constructed for 50 and 100 volts potential must not be used upon railway circuits, particularly where current is used for lighting purposes.

CLASS F.—BATTERIES.

Primary or Secondary Batteries.

1. Secondary batteries or accumulators should be placed in a light and well-ventilated place, preferably upon racks, and thoroughly well insulated.

2. Frequent examinations should be made of the connections and the specific gravity of the solution.

3. When current for light and power is taken from primary or secondary batteries, the same general regulations must be observed as apply to such wires fed from dynamo generators developing the same difference of potential.

CLASS G.—MISCELLANEOUS.

1. The wiring in any building must test free from "grounds" before the current is turned on. This test may be made with a magneto bell that will ring through a resistance of 20,000 ohms where currents of less than 250 volts are used.

2. No ground wires for any purpose may be attached to gas-pipes within the building.

3. All conductors connecting with telephone, district messenger, burglar alarm, watch clock, electric time and other similar instruments, must, if in any portion of their length they are liable to become crossed with circuits carrying currents for light or power, be provided near the point of entrance to the building with some protective device which will operate to shunt the instruments in case of a dangerous rise of potential, and will open the circuit and arrest an abnormal current flow. Any conductor normally forming an innocuous circuit may become a source of fire hazard if crossed with another conductor through which it may become charged with a relatively high pressure.

PHYSICAL SOCIETY.

At a meeting of this society on the 11th inst., Mr. Walter Baily, M.A., vice-president, in the chair,

A mathematical communication **"On Electromagnetic Induction in Plane, Cylindrical, and Spherical Current Sheets, and its Representation by Moving Trails of Images," Part I.: "General Equations,"** by **Mr. G. H. Bryan, M.A.**, was read by Dr. C. V. Burton, who also explained some of the parts in greater detail. After mentioning that the magnetic field due to induced currents in thin conducting sheets placed near moving magnetic poles could be represented by moving trails of images of those poles, the author goes on to say that in the paper the surface conditions which hold at the surfaces of the sheets are deduced directly from the fundamental laws of electromagnetic induction. I.: "The total current across any enclosed portion of a surface which always contains the same particles is equal to $\frac{1}{4}\pi$ of the line integral of the magnetic force round the curve bounding the surface"; and II.: "The rate of decrease of the surface integral of magnetic induction across any enclosed surface, which always contains the same particles, is equal to the line integral of E.M.F. round the curve bounding the surface." In addition to the above laws, the author makes the usual assumptions that displacement currents in the dielectric are so small as to be negligible, and that the induced currents are distributed uniformly through the thickness of the sheet. On these suppositions the surface conditions satisfied by the potentials at the two sides of a plane, cylindrical, or spherical sheets are determined, and, with an additional limitation as to the thickness of the sheet fulfilling certain conditions, extended to current sheets of other forms. In the latter part of the paper a synthetic determination of the images in a plane sheet is given and expressed in the form of a definite integral. In reading the paper to the meeting, Dr. Burton pointed out several misprints in the proof. **Prof. Minchin** showed that equation (1) of the paper ($\Omega_2 - \Omega_1 = 4\pi\phi$ + constant, where Ω_2 and Ω_1 are the magnetic potentials at the two sides of the sheet, and ϕ the current function) could be deduced by purely mathematical reasoning, instead of being based on the laws of electromagnetic induction. Moreover, it was true for any function whatever, and did not depend on ϕ being the current function. Equation (2) $\left(\frac{d\Omega_2}{d2} = \frac{d\Omega_1}{d2}\right)$ followed immediately from the fact that the magnetic force was continuous. The latter part of the paper might be simplified by integrating the linear partial differential equation (15) $\left(\frac{d^2\Omega^1}{dz\,dt} - R\frac{d^2\Omega^1}{dz^2} = -\frac{d^2\Omega_0}{dz\,dt}\right)$ in the ordinary way, for the form was one for which the auxiliary equations are well known. **Dr. Burton**, in reply, said he thought Mr. Bryan's reason for developing the equations from the laws of electromagnetic induction was to give his work a physical rather than a mathematical basis.

A paper **"On Dielectrics"** was read by **Mr. Rollo Appleyard**. In testing the insulation resistances of celluloid by having a sheet pressed between two metal plates, the author noticed that the resistance, which was very high, *decreased* as the time the testing battery was left on increased. The "electrification" (using the word to indicate the rate of diminution of galvanometer deflection) was, therefore, *negative*. The resistance also diminished greatly with increase of battery power, and a considerable amount of hysteresis was observed in the resistance at any given voltage, after a minute's electrification, depending on the previous history of the specimen. On making contact with the surfaces of the celluloid by mercury instead of by solid metal, the abnormal results disappeared, little or no resistance, hysteresis, or "electrification" being present, and only a small diminution of resistance with increase of voltage. For a six-mil sheet the resistance between opposite faces 5½in. diameter was of the order 30 megohms, and one specimen broke down at 1,200 volts. The celluloid condensers used in the experiments were found to discharge slowly at first, and after a certain time the deflections of the galvanometer became reversed and attained a steady negative value. This the author attributes to an E.M.F. of about 0·0006 volt between the mercury and celluloid. Similar experiments on guttapercha tissue showed no such E.M.F., and the "electrification" was normal. The resistance usually attained a maximum for voltages between 600 and 800. Although the tissue had a thickness of only two mils (0·002in.), it stood a pressure of 1,200 volts, and offered a resistance between circular faces 5½in. in diameter of about 3,000 megohms. The opaque white spots seen in celluloid under the microscope led the author to test the behaviour of mixtures of conducting and insulating materials. A strip of guttapercha was warmed, and coarse brass filings scattered over it as thickly as possible. In spite of this the resistance was practically infinite even when tested with 750 volts. A number of rods were made from mixtures of brass and guttapercha in various proportions, and on testing these it was found that if the weight of filings exceeded about twice that of the guttapercha, the resistance of a rod 20in. long, ⅜in. diameter, was small (sometimes a fraction of an ohm), whereas a slightly smaller proportion yielded rods having resistance measured in thousands of megohms. Such rods were found to be affected by oscillating discharges in a manner similar to Prof. Minchin's "impulsion" cells and M. Branby's tubes of filings. Experiments were also made on the behaviour of such rods when subjected to high alternating pressures. This caused small local arcs to form along the rods, but did not permanently destroy their high resistance.

In connection with Mr. Appleyard's paper, **"A Note on the Behaviour of Certain Bodies in Presence of Electromagnetic Oscillations,"** by **Prof. G. M. Minchin, M.A.**, was read by Mr. Elder. Referring to the employment of impulsion cells, metallic films, etc., for detecting the nodes of electromagnetic vibrations, he says that so far the physical states of such bodies are too variable to be of service. Metallic surfaces, formed by embedding fine metallic powders in films of gelatine, shellac, or sealing-wax, are, as described in a previous communication to the society, found to act as insulators, but become conducting when subjected to strong electromagnetic disturbances. After a current has once passed through such a film its resistance is changed by very feeble impulses, whereas previously it failed to respond to strong ones. On breaking contact by removing the electrode from the surface, the film loses its conductivity, the time necessary to do this depending on the hardness of the matrix. The resistance of a film containing tin powder, measured between the rounded tips of two platinum wires 1cm. apart, varied under the electromagnetic impulses from ∞ to 130 ohms. In conclusion, the author points

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out that with films and tubes the whole phenomenon relates to change of resistance, whereas impulsive cells may have currents from external sources passing through them whilst in either the sensitive or insensitive states. **Mr. Bright** and **Mr. Enright** asked questions as to the electrification of guttapercha and the bridge connections in the resistance tests of the semi-conducting rods respectively, to which **Mr. Appleyard** replied.

BUSINESS NOTES.

Western and Brazilian Telegraph Company.—For the past week the receipts were £2,891.

Toxteth.—The Board of Guardians are considering the question of lighting the workhouse by electricity.

Guildford.—The Town Council have again discussed the question of the provisional order, referred to in our last issue.

Liverpool Overhead Railway.—The traffic receipts of this railway for the week ended 13th inst. amounted to £824.

Dundee.—During the past month 504 Board of Trade units of electricity were supplied to the four arc lamps on High-street, at a cost of £10. 10s.

Winchester.—The county surveyor is to report to the County Council on the question of introducing the electric light into the new offices.

Coatbridge.—The Town Council are to ask the electric lighting company to estimate for the lighting of the streets over the area covered by their plant.

Birkenhead.—The Mersey Docks and Harbour Board intend to construct a new jetty at Birkenhead at a cost of £7,500. It is to be lighted by electricity.

Wolverhampton.—The Local Board of Health of Heath Town, Wolverhampton, propose to consult an electrical engineer on the subject of electric lighting.

Worcester.—The tender of the Brush Electrical Engineering Company has been accepted, at £1,861, by the Town Council for laying mains for 26 arc lamps.

Weston-super-Mare.—The Town Commissioners have sent out papers asking for the names of those willing to take the electric light. A number of favourable answers has now been received.

Burnley.—Various alterations have been made at the Central Club, and the electric light has been installed by Messrs. Spagnoletti and Crookes, under the local management of Mr. E. H. Berry.

Removal.—Messrs. King and Co. inform us that they have removed from Edinburgh to new business premises in Leith, and that their address is now at Leith Electric Works, Prince Regent-street, Leith.

Derby.—Messrs. J. Davis and Son have received instructions from the Corporation of Derby to instal arc and incandescent lamps, with distributing boards, measuring instruments, etc., for lighting the Market Hall, galleries, and approaches.

Wrigley's Patent, Limited.—This Company has been registered with a capital of £60,000 in £1 shares. The object is to acquire certain patents granted to Thomas Wrigley, and to carry on business as ironfounders, mechanical and electrical engineers.

Electric Lighting Concessions.—"Malaysia," care of Messrs. Street and Co., Cornhill, announces that he has electric light concessions for disposal for Oriental towns of 120,000 and 30,000 inhabitants, with contingent Government contracts or subsidies for lighting.

Chertsey.—At a meeting of the Rural Sanitary Authority Mr. Chambers said the Weybridge Parochial Committee had decided to call the attention of the electric lighting company to the poles in the village. They thought something ought to be done in reference to pulling them down

Ballymena.—The Town Commissioners, in connection with the proposed lighting of the locality by electricity, have expressed an opinion that until a much less expensive scheme than the one which they had been recently asked to consider were put forward, they would not be in a position to entertain it.

Eton.—The Local Board have received a communication from the Windsor Electric Lighting Committee of the Town Council suggesting a consultation with the Board on the subject of electric lighting. A committee of five members of the Board has been appointed to meet a sub-committee from Windsor.

Tenders for St. Pancras.—The Vestry of St. Pancras invite tenders for the buildings to contain the electric lighting plant (engines, dynamos, boilers, etc.) to be carried out at the electric lighting and refuse destructor station, King's-road, Camden Town, N.W. Tenders are to be sent in by Monday, 21st inst.

City and South London Railway.—The receipts of the Company for the week ended May 13 were £905, against £787 for the same period last year, or an increase of £118. The total receipts for the first half-year of 1894 show an increase of £364 compared with those for the corresponding period of 1893.

Stafford.—The Electric Lighting Committee of the Town Council have received the report of Dr. Hopkinson on the engines for the electric lighting station. The committee advised the purchase of three horizontal compound steam-engines from Messrs. Marshall, Sons, and Co., for £2,420. The report has been adopted.

British Aluminium Company, Limited.—This Company has been registered with a capital of £100,000 in £10 shares. The object is to acquire any mineral, clay, and other deposits suitable for the production of aluminium, sodium, and other metals; also the rights for getting the same, and the production and supply of electricity.

Church-Lighting.—Messrs. Rashleigh Phipps and Co. have received instructions from the Marylebone Presbyterian Church, Upper George-street, Edgware-road, to instal an additional 200 lights in the church. This is the second order placed in the hands of this firm, who lighted the vestries and committee-rooms in the autumn of last year.

County of London and Brush Company.—The Board of the County of London and Brush Provincial Electric Lighting Company have passed resolutions appointing the Right Hon. D. R. Plunket, Q.C., M.P., and Mr. Anthony Noel Denny, directors of the Company. The directors also passed a resolution electing the Right Hon. D. R. Plunket as chairman of the Board.

The Strand District.—The Strand District Board of Works have referred to the Works Committee an application of the secretary of the Charing Cross and Strand Electricity Supply Corporation for the Board's sanction and approval to a provisional order from the Board of Trade, so as to enable the corporation to supply electrical energy within the parish of St. Paul's, Covent Garden.

Bolton.—The electrical engineer to the Corporation has been requested by the Gas and Electricity Committee to prepare a scheme for carrying out a hire-purchase system of electrical fittings, by which consumers can both hire and purchase the fittings simultaneously. Good progress is being made with the electricity works, and the laying of the underground mains has been commenced.

Tenders for Tunbridge Wells.—The Corporation invite tenders for the construction, supply, and laying down of the necessary plant and mains for the supply of electricity in the borough, in accordance with the specifications, plans, and form of tender which can be obtained from Mr. W. C. Cripps, town clerk, Town Hall, Tunbridge Wells, on payment of £2. 2s. Tenders, endorsed "Electricity," are to be delivered at his office not later than June 6.

St. Bride's Church, Kelvinside, Glasgow.—This church is to be lighted by electricity. The supply will be taken from the mains of the Kelvinside Electricity Company. This is the first church in the district to be lighted by electricity; the plans and specifications were drawn out by Mr. W. Elsdon Dew, resident engineer to the supply company, and the contract has been placed in the hands of Messrs. Claud Hamilton, Limited, Glasgow. Other churches in the district have been considering the advisability of keeping up with the times.

Windsor.—The Town Council have received a memorial with regard to the electric light. The Mayor, at a meeting last week, suggested that the memorial should be referred to the Electric Lighting Committee. The substance of the memorial was a request that the Council would urge matters on as quickly as possible with regard to the supply of the electric light. Councillor Reavell said it would be sufficient if the reference to it was seen in the newspapers' record of the meeting.

Edinburgh.—A deputation has been received by the Town Council on the subject of the recent order concerning the removal of overhanging signs and lamps. It was pointed out by one of the deputation that as they were about to get the electric light, and a great many traders intended to have arc lamps placed outside their business premises, it would be a very great hardship for them to go to the expense of £50 or £60 for lamps and then get an order afterwards for their removal.

Larne.—Mr. J. D. A. Norris, the receiver and manager of Messrs. J. H. Gordon and Co., Limited, electrical engineers, has acknowledged the receipt from the Town Commissioners of £112. 10s. on account of lighting the town to April last. The Commissioners have spent considerable time in going over the clauses contained in an agreement to be entered into with Messrs. J. H. Gordon and Co., Limited, for the lighting of the town for the ensuing three years. Several clauses which had been struck out or amended by the receiver and manager of Messrs. Gordon and Co., have been reinserted by order of the Commissioners.

Brighouse.—At a meeting of the Town Council, held under the chairmanship of the Mayor (Alderman William Smith), a letter has been read from Mr. George Furniss, solicitor, Brighouse, asking for the consent of the Corporation to the obtaining by a proposed local company of a provisional order to take over the plant of Mr. A. B. Brooke, Brighouse, and to supply electricity in the borough for lighting or other purposes. The Mayor proposed that the consent of the Corporation be withheld, and spoke strongly in favour of the Council taking the electric lighting of the borough into its own hands. Alderman Kershaw seconded this, and the motion was carried.

Cheltenham.—The borough surveyor has been authorised, as he required assistance in the electric light department, to employ an assistant at a cost not exceeding £20 per month, such assistant to hold office until the appointment of a permanent electrician at a commencing salary of £200 per annum, rising by annual instalments of £10 to £250. The surveyor has also been authorised to obtain 15,000 yards of tubing for carrying the electric cables, at a cost of 35s. 5d. per 100ft., from Mr. W. C. Hawtayne, of Victoria street, S.W. The Town Council have resolved to postpone the question of providing a gas-testing station till the question of providing an electric light testing station comes up for discussion.

Chagford and Devon Company.—The shareholders of the Chagford and Devon Electric Lighting Company met on Friday, Mr. Eaton presiding. The manager (Mr. G. H. Reed) reported that fresh applications for additional light were constantly being

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received, and that the light continued to give satisfaction. The Company was now making satisfactory progress, and was expected shortly to be in a position to pay a dividend. Mr. Reeves, a director, stated that he had examined the works thoroughly, and, as a practical electrician, had pleasure in reporting that the works had been carried out and the cables laid in a manner highly creditable to Mr. Reed, and that the whole was now in a satisfactory condition.

Coventry.—At a recent meeting of the Town Council, the Electric Lighting Committee reported that Mr. Hammond and Mr. George Steane had attended the committee with plans and specification of the proposed electric lighting station, which were approved. It was ordered that advertisements for tenders should be inserted. The General Works Committee reported last week that at their meeting on the 1st inst. a letter was read from Mr. Graff Baker with respect to the tramways, asking that the question of giving notice to terminate the agreement of April 17, 1893, be postponed for a further period of one month. The committee ordered that the matter be postponed for one month from the 1st inst., and that Mr. Baker be informed that the committee cannot consent to the system of cross suspension in the Warwick-road.

Taunton.—Mr. Harold W. Cousens, the electrical engineer to the Taunton Town Council, reports that the staff have erected the small engine and alternator, and are working them regularly on Sundays, and during the hours of light load. No. 1 transformer sub-station is now in full working order, and there are 480 16-c.p. lamps connected to the low-tension cable. Steam has been raised in the boiler. All consumers on the incandescent circuits (save eight with an average of three lights each) are now charged by meter. During the past quarter 124 additional 16-c.p. lamps have been added to the mains. Mr. R. W. Phillips and Mr. E. B. Thornhill, assistant electricians, have received an increase in their salary of £15 per annum. Tenders for the supply of 1,500 tons of coal to be supplied during the ensuing year are to be advertised for.

Electric Lighting at Cardiff.—The Corporation Lighting Committee, who met on Tuesday, had before them a letter from Mr. W. H. Massey, the electrical engineer, reporting progress of the work in connection with the electric lighting of Cardiff. All the pipe-laying was finished, and the outside work would be finished as soon as Mr. Harpur could fix the exact position of a few refuges still to be made. All the machinery would soon be delivered. At the suggestion of Mr. J. M Gerhold, it was decided to advertise for four mechanical engineers to attend to the electric light plant. Mr. S. Brain asked when it was probable that the works would be opened. Mr. Fletcher (Mr. Massey's deputy) stated that they would be ready to supply the town about the middle of July. The Mayor stated that most of the profit of the undertaking would accrue from the lighting of business premises, and not from street-lighting. Alderman Jacobs said they had previously agreed that a pamphlet dealing with the advantages of lighting by electricity should be printed, and he suggested that such pamphlets be got out forthwith and distributed. The Mayor also asked if the time was not opportune to go into the charges for the supply of electric light It was decided to proceed with the arrangement of the pamphlet at once, and it was suggested that a scale of charges be embodied therein.

Buckingham.—The Lighting Committee of the Town Council have considered the following letter and tender sent in by Messrs. Parr and Gillies on the subject of electric lighting: "We have carefully considered the above matter, and beg to inform you that we are prepared to light the town either on the arc or an improved incandescent system. In the former, we propose to use 34 lamps of 1,200 c.p. nominal, distributed about the town in such position as we deem would give the best effect. The cost of this system would be £165 per annum. On the incandescent system, we suggest about 60 lamps, varying from 16 c.p. to 100 c.p., according to position. The cost of this system would be £145 per annum. We have experienced considerable difficulty in working out the best system, as there are several points in each scheme which would require to be discussed with you, and which might probably reduce the cost. In either case, all the lamps would be controlled from the central station, and have the same lighting hours. In the event of either scheme, or some modification thereof, being accepted, we should require a contract for a period of not less than five years. We would suggest that a committee be deputed to discuss the matter with us, when we shall be pleased to explain fully the plans and details of each scheme." The Town Council decided to adjourn the matter in order to enable the Lighting Committee to have an interview with Messrs. Parr and Gillies; and also to make enquiries from towns where paraffin-oil lamps are used for public lighting.

Ayr.—The Ayr Town Council have further considered the question of introducing the electric light into the burgh. An exhaustive and elaborate printed report, drawn up under the instruction of the Council by Mr. Hammond, was submitted, and the town clerk read a letter from Mr. A. F. Carmichael, on behalf of the Caledonian Electric Supply Company, Edinburgh, containing an offer to introduce an installation of the electric light under transfer of the rights of the Corporation contained in their provisional order obtained some years ago. A long discussion ensued. Mr. James Smith, convener of the Lighting Committee, moved, and Mr. Ure seconded, that the Council proceed with the installation of the electric light under the provisional order obtained several years ago. Mr. W. Beveridge moved, and Mr. W. Smith seconded, that a plebiscite of the inhabitants be taken on the question; Bailie Willcock moved, and Captain Galloway seconded, that the offer of the Caledonian Company or some other company should be considered, and overtures made to them by the Council. In the course of the discussion, Mr. W. Auld, a representative of the Third Ward, stated that he had taken a plebiscite of the ratepayers in that ward on the question, and the result was that he had found 75 per cent. of those who had voted were in favour of the introduction of the electric light. After divisions had been taken it was agreed to instruct Mr. Hammond to proceed with measures for the introduction of the electric light, and it was remitted to the Lighting Committee to act along with Mr. Hammond. It is estimated that the first cost of the installation will be about £15,000.

Lighting of Mills and Country Residences.—Messrs. John Davis and Son are engaged upon a large lighting and power plant for Messrs. F. Longdon and Co.'s mills in Derby, the number of lamps being over 500, of candle-powers varying from 8 to 32. There are motors of from ½ h.p. to 5 h.p. for working sewing machines, lifts, etc., and with a view to economy, a special change-over arrangement is fixed in the engine-house, so that should only a few lamps be required at any time in any part of the building, connection can be made to the Corporation supply mains without putting out the light even for a moment. The firm are also engaged on several complete plants for country residences. One completed at The Cedars, Breadsall, consists of an oil-engine, dynamo, a set of 53 accumulators, and switch-board, complete with regulating and starting switches, automatic safety fuses, alarms, etc. The oil used is paraffin, of the Royal Daylight brand; this is converted into a vapour by being pumped through a red-hot tube, then automatically mixed with a correct amount of air, and passed into the cylinder, where it is exploded in the same manner as coal gas is in the now well-known gas-engines. Every detail of the plant has been most carefully studied and designed for economy. Gas and oil engines being sometimes a little difficult to start, Messrs. John Davis and Son have overcome this difficulty by an arrangement on the switchboard, by means of which the current from the accumulators is made to drive the dynamo as a motor, and this in turn drives the engine until it has attained its speed, when it automatically takes up its work and charges the accumulators. There are nearly 100 lamps of various candle-power installed in the house. In this age of £ s. d. an idea of the cost of working such a plant may be interesting. From tests recently made it was found that the cost of the oil used in the engine was ½d. per horse-power per hour, and the cost of the light equal to gas at 2s. 6d. per 1,000 cubic feet, full allowance being made for the depreciation of the plant. Another point in connection with this plant is that by a single and ingenious contrivance the firm have almost entirely done away with the noise which is, as a rule, a disagreeable adjunct to all moving machinery. So far successful is this arrangement that within five yards of the engine-house neither smell nor noise is discernible. An almost identical plant is now being installed at the Duffield residence of Mr. Abraham Woodiwiss.

St. Pancras v. City Lighting.—Mr. H. H. Bridgman, in the course of a communication to the *City Press*, says: "A contemporary has called attention to a statement by Mr. Preece, the electrical adviser to the Commission, wherein he is represented as saying that the electric lighting in the City costs £27 per lamp, whilst in St. Pancras the cost is only £17 per lamp, and suggests by way of explanation that the City should have undertaken its own electric lighting the same as St. Pancras did, instead of allowing contractors to do it, and so reap all the benefit. I have not read the actual statement said to have been made by Mr. Preece, but as I consider him to be as discreet and accurate as he is capable as an electrician, I feel satisfied he would not have given utterance to such an expression without duly qualifying the same. In the first place, the contract price of the City lamps is not £27, but £26 each per annum, and the answer to the alleged statement as to the difference of cost per lamp will give a very different complexion to the subject; but for the fact, however, of the City electric light contractors having the private lighting of the City as well, the cost would not be so low as £26 per lamp. I happen to be a member of the St. Pancras Vestry as well as a Commissioner of Sewers, and I very much question the accuracy of the price named per lamp in St. Pancras. I have not the reports by me, but my impression is that the cost is very considerably higher than £17 per lamp. The figures given, however, are sufficient for my present purpose, as I may have to return to the subject again. In St. Pancras, 86 arc lamps displaced 479 gas lamps. In the City 479 arcs displaced 1,258 gas lamps, or, in other words, each arc lamp in St. Pancras displaced 5½ gas lamps, whilst in the City each arc displaced only 2⅝ gas lamps. This means that practically in the City the arcs are only half the distance apart that they are in St. Pancras. If therefore the number of lamps in St. Pancras were doubled, the cost of lighting would practically be doubled. The lamps I should say are the same nominal power—viz., 2,000 candles—both in the City and St. Pancras, whilst the distance between the gas lamps was about the same. Now a simple calculation will show that, distance for distance, the St. Pancras arc lamps compared with those of the City ought only to cost £13 per annum each, whereas £17 per lamp shows an excess in cost of 31 per cent. on the cost of the City lamps. I do not write with the slightest thought of disparaging St. Pancras. On the contrary, I think it says much for the pluck of the Vestry that they should be the first of the metropolitan parishes to embark in so bold an enterprise as to light the streets by their own installation; but personally I have always considered in this matter of electric lighting that it is rather beyond the province of the local authorities to risk the ratepayers' money in enterprises which must be largely experimental, whilst there are so many public

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companies with private funds at their back to compete for the work of developing the principle of electric lighting. Monopolies are not created thereby, because there is ample provision made by Act of Parliament enabling local authorities to buy up the electric light companies on fair and equitable terms if purchase should be deemed desirable. This option is very important to public authorities. The public and private lighting of the City by electricity is a great work, and, including the cost of the sites of the generating stations, has involved an expenditure of very nearly a million capital (£972,000). This includes the erection of buildings, the equipment of the three stations, and the distribution, and provides for 515 arcs and 906 incandescent lamps of 200 watts each for the public lighting of the streets, as provided for in the contract with the Commissioners of Sewers, as well as for equipping the stations and providing plant for the supply and conversion of current for private lighting in accordance with detailed specifications and schedules of prices approved by the Commission, necessitating an output of 1,000 kilowatts for public and other arc lighting, and 12,100 for private lighting—in all 13,100 kilowatts; and the cost has worked out at £75 per kilowatt. The carrying out of the work, with the exception of the delay and inconvenience occasioned chiefly by the laying of the mains in such crowded thoroughfares in the City, has been, on the whole, considering the enormous amount of work done, very satisfactory; and this satisfaction, so far as the public lighting is concerned, is emphasised by the fact that the gas lamps are now being removed from all the main thoroughfares. The public lighting is practically perfect, the failures, if they can be so called, being infinitesimal, and in my humble opinion, taken as a whole, the action of the Commissioners of Sewers throughout has been so sensible and businesslike that if the entire business had to be now begun I do not see how they could much improve on the lines they have followed. The delay in the carrying out of the private lighting has been also, to a large extent, consequent on the difficulties of obtaining sites for the numerous transforming stations for regulating the supply, of which there are, I think, 42 equally distributed over the City, being in nearly every instance placed underground, involving necessarily great expense in construction and elaborate fitting. Now that the work is practically completed, I think the City may be congratulated that it has been entrusted to such an enterprising and energetic company."

PROVISIONAL PATENTS, 1894.

MAY 7.

8982. **Improvements in dynamo-electric machines.** Thomas Barnet Grant, 15, George-street, Mansion House, London.

MAY 8.

9117. **Improvements in and relating to electromagnetic tools.** Peter Jensen, 77, Chancery-lane, London. (G. Fonda, ——.) (Complete specification.)

9123. **Improvements in and relating to electric railways.** Hiram Stevens Maxim, 45, Southampton-buildings, Chancery lane, London.

9129. **Improvements in electrolysis.** Henry Blumenberg, jun., 4, South-street, Finsbury, London.

MAY 9.

9178. **An electrolytic meter for measuring electric currents.** Addison Goodyear Waterhouse, 33, Old Broad-street, London.

9184. **Improvements in conductors for the distribution of electrical energy and the insulation thereof.** George Wilkinson, 73, St. Stephen's-road, Upton Park, London.

9215. **Improvements in the system of circuit control for electric machines.** Charles Ervin Davis, 321, High Holborn, London. (Complete specification.)

MAY 10.

9285. **Improvements in or relating to electrodes and method of manufacturing the same.** Carl Kellner, 46, Lincoln's-inn-fields, London.

9292. **Improvements in or connected with electrolytic cells.** Edward Augustus Allen, 47, Lincoln's-inn-fields, London.

9295. **Improvements in electric lamps for bicycles and similar vehicles.** Henry Harris Lake, 45, Southampton-buildings, Chancery-lane, London. (George Mayr, United States.)

MAY 11.

9328. **An improvement in and relating to apparatus for electrolysis.** Benjamin Hooker, Pear Tree-court, Farringdon-road, London.

9342. **Improvements in the methods of electrically coating wire tubes and similar articles.** Richard Heathfield and William Stepney Rawson, 1, Leadenhall-street, London.

9348. **Improvements relating to electric lighting.** Alexander Wilson, 124, Chancery-lane, London.

9350. **Improvements in apparatus for electric lighting by means of primary or secondary batteries** Arthur Ford-Lloyd, 2, Phœnix-place, Mount Pleasant, London.

9351. **Improvements in apparatus for testing telephone lines.** Charles Herbert Elliot, Elmer's End, Beckenham, Kent.

9357. **Improvements in and relating to electric arc lamps and their construction.** Walter Rowbotham and Euphemia Rowbotham, Tintern Lodge, Upper Chorlton-road, Whalley Range, Manchester.

9362. **Electric alarm clocks with advertising spaces.** Samuel Sidney Bromhead, 97, Newgate-street, London. (Franklin Beuner, United States.) (Complete specification.)

9364. **An improved lubricant, chiefly designed for use on the collectors of dynamo-electric machines.** David Young, 11, Southampton-buildings, Chancery-lane, London. (Jacques Marius, Italy.)

9368. **Improvements in electric fuses.** Frank Brain, 1, Furnival-street, Holborn, London.

MAY 12.

9399. **A combination of the electric overhead trolley system and the electric accumulator system for railways and tramways.** Alfred Dickinson, Birmingham-road, Darlaston.

9410. **Improved means of gripping cords, wires, or the like, for electrical or other purposes.** Charles Henry Cutting, George Hawkins Ctuting, and Isabella Cutting, Imperial-chambers, Albert-street, Derby.

9437. **Improvements in the method of and apparatus for regulating the amount of light from electric glow lamps.** Henry Lea, 18, Southampton-buildings, Chancery-lane, London.

9456. **Improved junction or fuse box for electric wires.** Charles Newton Russell, 166, Fleet-street, London.

SPECIFICATIONS PUBLISHED.

1892.

19953. **Electrodes.** Richardson. (Second edition).

1893.

2267. **Electrolytic separation of bases of salts, etc., from saline solutions.** Vautin. (Second edition.)

10130. **Driving vehicles on electric rail or tramways.** Pieper.

10648. **Electric light and heat stove.** Mitchell.

12142. **Electrical railway switch.** Tyer.

14472. **Switch for shop-door bell circuits, etc.** Barkshire and Wright.

22912. **Secondary batteries.** Wheeler.

1894.

3658. **Dynamo-electric machines.** Hall.

3962. **Electrical switches.** Dorman and Smith.

4987. **Arc electric lamps.** De Segundo.

5025. **Electric rail or tramway systems.** Smith.

5271. **Electric railways.** Brown.

5273. **Electric railways.** Barker. (Lawrence Electric Company.)

COMPANIES' STOCK AND SHARE LIST.

Name.	Paid.	Price Wednesday.
Birmingham Electric Supply Company	5	5½-6½
Bournemouth Electric Company	—	—
Brighton and Hove Company Original	100	210-215
Brush Company, Ordinary	3	2⅞-3
—— Nom. Cum., 6 per cent. Pref.	2	2⅛-2⅜
—— 4½ Debenture Stock	100	108-111
Charing Cross and Strand	5	4½-5
Chatham and Rochester	—	—
Chelsea Electricity Company	—	—
City of London, Ordinary	10	12-13
—— 6 per cent. Cumulative Pref.	10	13½-14
—— 5 per cent. Debenture Stock	75	33-35
City and South London Railway, Consolidated Ordinary	100	29-31
—— Debenture Stock	100	109-111
—— 5 per cent. Pref. Shares	10	11-11½
Crompton and Co., 7 per cent. Cum. Pref. Shares	5	3-3½
—— 5 per cent. First Mortgage Debentures—1-400 of £100 and A, 1-200 of £50	100	95-100
Elmore's French Company	2	5/16-7/16
Electric Construction, Limited	2	⅛-¼
—— 7 per cent. Cumulative Pref.	2	1⅛-1⅜
Elmore's Copper Depositing	2	1⅛-1⅜
Electricity Supply Company for Spain	5	—
Elmore's Wire Company	2	1⅜-1⅝
Fowler-Waring Cables	5	¼-½
W. T. Henley's Telegraph Works, Ordinary	10	6½-7½
House-to-House Company	5	½-1
India Rubber and Gutta Percha Works	10	23-24
—— 4½ per cent. Debentures	100	102-104
International Okonite, Ordinary	10	1-2
Kensington and Knightsbridge	5	4⅜-5½
Liverpool Electric Supply, Ordinary	5	6⅜-6½
—— Pref.	4½	5½-6⅜
Liverpool Overhead Railway	10	7½-7⅝
—— 4 per cent. Mortgage Debentures of £100	100	107-109
London Electric	5	¼-½
Metropolitan Electric Supply	10	7⅛-8
—— 5 per cent. Reg. Debentures, 1-10,000 in Bonds of £10, £20, and £40	—	108-111
National Telephone, Ordinary	5	4½-5⅛
—— 6 per cent. Cum. First Pref.	10	15-16
—— 6 per cent. Cum. Second Pref.	10	14½-15½
—— 5 per cent. Nom. Cum. Third Pref.	5	5⅛-5⅜
—— 4½ per cent. Deb. Stock	—	114-116
Notting Hill Company	10	4½-5⅛
Oriental and Electric Company, £1 shares	1	¾-1⅛
Southampton Electric Company	—	—
St. James's and Pall Mall, Ordinary	5	6⅞-7½
—— 7 per cent. Pref.	5	8-8½
Swan United	2½	1⅜-1⅝
Telegraph Construction and Maintenance	12	39-41
—— 5 per cent. Bonds	100	104-107
Westminster Electric Supply, Ordinary	5	5⅜-6⅛
Yorkshire House-to-House	4½	4⅛-4⅜

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NOTES.

Newport (Mon.).—The site of the central station is in Canal-parade.

The Kinetoscope.—Mr. Edison is reported to be now completing this apparatus.

Telegraphy.—The telegraph line between China and Burmah will be completed this year.

Dover.—An exhibition of electrical apparatus has this week been held in the Connaught Hall.

Budapest Lighting.—Large extensions are to be made this year in the laying of electric light mains.

Electric Lighting in Gorlitz.—The local authorities have decided to introduce the electric light into the town.

A Car on Fire.—An electric car caught fire a short time ago in Brussels, but the flames were soon extinguished.

Calcutta.—The Calcutta Electric Lighting Bill and the Calcutta Tramways Act are being considered by the Indian Government.

Electric Clocks.—The journal *L'Electricien* of May 19 contains an illustrated description of the Cauderay system of clock regulation by electricity.

Central London Railway.—The Central London Railway (Extension of Time) Bill was read a third time in the House of Commons on Monday.

Karlowitz.—Messrs. Egger and Co. are fitting the palace of the Servian Patriarch with the electric light. There will be 200 incandescent lamps.

Wolverhampton.—As mentioned in another column, the Mayor of Wolverhampton laid the foundation-stone of the municipal electricity works on Monday.

Dear Gas.—At Moy, in Ireland, the price of gas averages about 8s. 6d. per thousand. There should be an opportunity here for a supply of electricity.

Concert.—The fourth of the series of concerts given in Belfast under the auspices of the National Telephone Company was given in the offices of the company last Friday.

The Solent.—The Royal Engineers have completed a system of electric search-lights for illuminating the Solent at night, thus affording protection against night attacks.

Jena.—Telephonic communication is to be established between Jena and Weimar, with connections with Erfurt, Gotha, Eisenach, Naumburg, Halle, Weissenfels, and Leipzig.

The Foreign Office.—The Foreign Office is being wired for the electric light, which will be switched on on the occasion of the official celebration of the Queen's birthday.

Another Eiffel Tower.—It is proposed to build an Eiffel tower outside Copenhagen. It will be lighted electrically, and it is possible that the lifts will be operated by electricity.

Transylvania.—Telephony is making considerable progress in Transylvania. A telephone system has been established between Klausenburg and Gyalu. Other extensions are in progress.

Electric Lighting in Krone.—A commission has been appointed by the Municipality to consider the question of lighting the town electrically. There is 300 h.p. of water power available.

Water Power.—The Société Lyonnaise des Forces du Rhone is about to commence operations in the carrying out of the undertaking for the utilisation of the waters of the Rhone for electric light and power purposes.

Newington.—The Local Government Board have sanctioned the loan of £33,000 for the erection by the Newington Vestry of baths and wash-houses, which, it will be remembered, are to be lighted by electricity.

Offenbach-on-the-Maine.—The municipal authorities are going to erect a small electric lighting station, the plant to be driven by gas-engines. The price for incandescent lamps per hour is to be 4pf., or, say, about ½d.

Award.—In connection with the recent distribution of prizes in the Glasgow and West of Scotland Technical College, Mr. J. Fred. Nielson has been awarded the Sir John Pender medal for excellence in electrical engineering.

Steam Traction in Paris.—A French contemporary in its current issue describes and illustrates the Serpollet system of steam traction for tramways, and which it is proposed to introduce in Paris in competition with the electric cars.

West Metropolitan Tramways.—The West Metropolitan Tramways will be put up to auction on the 13th prox. by Messrs. Edwin Fox and Bousfield. It will be remembered that it was on these lines that the Lineff system was to have been tested.

Electric Tramway at Nuremberg.—Messrs. Schuckert and Co. are preparing plans for an electric tramway between Nuremberg and Erlangen. The State railway system makes a long detour, but the tramway will be carried by a direct route.

Electric Power Pumping Station.—At Babolna, Hungary, a small electric power station is being erected in order to pump from a stream, about three-quarters of a mile distant, water for agricultural purposes. Messrs. Egger and Co. have the work in hand.

Newcastle Tramways.—The Newcastle Tramways Committee have again considered the question as to the best system to be adopted for the working of the tramways. A long conversation took place concerning the electric and cable systems, and it is reported that the general feeling seemed to favour the latter.

News by Telephone.—The account of the execution of the Anarchist Henry in Paris, which appeared in the evening papers on Monday, was sent to London by telephone. It was sent by the Central News, who often use the telephone for the transmission of important news from Paris. The telephone is dearer, but much quicker than the telegraph.

French Civil Engineers.—The members of the Société des Ingenieurs Civils de France will make their annual excursion this year to Belgium, commencing on July 15, and terminating on the 22nd idem. Visits will be paid to various works, and those intending to be present must acquaint the secretary by June 20, the offices being at 10, Cité Rougemont, Paris.

Electricity v. Gas.—Alderman Pollock, in bringing up on Tuesday the report of the Gas Committee to the Birmingham City Council, which showed a decrease of consumption of gas last year, said that it was evident that the competition of the electric light was seriously checking the consumption of gas, and that the application of electricity for illuminating purposes would grow.

Vienna Electric Tramways.—We have referred at various times to electric traction projects in Vienna, and now note that the *Zeitschrift für Elektrotechnik* of Vienna remarks that there is no scarcity of schemes, but that if the practical carrying out of the projects continues to go on as in the past, the Viennese public will be using the Wellner air-ship before they travel by an electric line.

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Municipal Electric Lighting at Nuremberg.—The Municipality have decided that the central electric lighting station shall be erected outside the town at Tullnau. Mr. Oskar von Miller has been instructed to work out plans for an alternating-current scheme, and for alternating current transformed into continuous current.

Curtice's Newspaper Index.—A copy of the first volume relating to the quarter July-September has reached us. It is an index to practically everything published during that period in the *Times*, the London morning and evening papers, and in a number of weekly and provincial newspapers. The volume may be of use to public men, but to the majority of the community it does not appeal.

The Leipzig Electrical Exhibition.—The list of applications for space at the electrical exhibition which is to be held at the Crystal Palace, Leipzig, from June 8 to June 17 has now been closed. In spite of the short duration of the exhibition, and of people being tired of exhibitions, the show promises to be a very good one. Dr. Wiedemann has been elected president and Dr. Föppl vice-president of the exhibition.

Electric Colouring of Hides.—According to *Electricité*, a new process for colouring hides consists in spreading the skin on a metal table, covering all the surface with the exception of the edges with the colouring liquid, and passing an electric current between the liquid and the table. The effect of the current is, as in electric tanning, to open the pores of the hide, thus allowing the solution to penetrate better and to give a more durable colour.

A Convivial Gathering.—On the 5th and 6th June, just before the opening of the meetings of the Union of German Electrical Engineers, the third annual gathering will take place, at Leipzig, of the Freie Vereinigung der Vertreter von Elektricitätswerken. This society meets every year for the purpose of a convivial assembly, and for an interchange of opinions between the representatives of German electricity works. No papers are read at the meetings.

Electric Lighting at Mittewald.—A small but interesting central electricity station is being erected by Messrs. B. Egger and Co., of Vienna and Budapest, at Mittewald, near Villach, a favourite health resort. The various public buildings are to be lighted electrically from this station, and power is obtained from a high-pressure turbine working under a head of about 800ft. The turbine will be coupled direct to a dynamo running at 900 revolutions per minute.

Underground Railways in London.—We understand that no very decided step will be taken at present with regard to developing the various projects so far authorised for railways on the Greathead system, excepting only the Waterloo and City line. The extensions of the City and South London Railway are dependent mainly upon financial arrangements not yet completed, whilst the Central London Railway promoters are waiting to bring their scheme before the public for financial support at the most favourable opportunity.

Personal.—Mr. Graham Harris, Sir Frederick Bramwell's partner, has been asked by the Electric Lighting Committee of the Derby Town Council to deliver an address in connection with the electrical exhibition now being held in that town, and to which reference was made in our last issue. The lecture given by Sir Frederick Bramwell last week is reproduced in another part of the present issue. Mr. F. Uppenborn, who, we believe, is about to retire from the editorship of the *Elektrotechnische Zeitschrift*, has been appointed municipal electrical engineer to the city of Munich.

Search-Lights for Armoured Trains.—A new armoured train has been tested on a branch line between Newhaven and Seaford. Colonel Boxall, to whom credit is due for the new arrangement, considers that the ideal train is a battery of four or six heavy guns, mounted on two, three, or four trucks, with heavy armour plate, another truck with a powerful search-light and dynamo attached, which truck would follow immediately after the engine or be in front of it, and would, of course, be taken away with the engine before the battery was brought into action, and two or three coaches full of men, ammunition, stores, etc. An application which has been made for the search-light has not yet been granted.

The Hampstead Station.—Preparations have been for some time in progress, under the direction of the Hampstead Vestry, for lighting that suburb by means of electricity. The cost of plant for lighting the whole parish is estimated at £80,000, but at present provision is only being made for lighting the compulsory area under the provisional order obtained by the Vestry. The cost of the buildings now approaching completion is about £7,500, and that of the electrical plant for lighting the compulsory area is £19,794. Mr. Churchwarden Thwaites, chairman of the Vestry's Electric Lighting Committee, on Wednesday performed the ceremony of placing a memorial-stone in position at the new buildings in the presence of a number of the members of the Vestry and others interested in the undertaking.

Telephone Working and Electric Tramways. The subject of disturbances set up in telephone wires by the working of electric tramways is discussed by Messrs. O. E. Meyer and K. Mützel, in the *Elektrotechnische Zeitschrift* of May 17. The authors investigated the question as to whether the cause of disturbances in telephone wires is due to the overhead conductor or the return through the ground. They made a series of experiments in Breslau, and state that the noises heard in the telephones arose from the current induced therein from the trolley wire, due to the changes in the current strength in the conductor. The authors conclude that the earth currents contribute but little to the noises heard in the instruments, and they leave to practical men the provision of an effective insulator for telephone wires.

Thomas Parker, Limited.—In a recent issue we referred to the registration of this Company, and we now note that it is inviting subscriptions to shares. The capital of the Company is £75,000, divided into 7,500 shares of £10 each. Of these, 4,500 shares have already been taken up, and the balance of 3,000 shares has been offered for subscription. The Company has been formed to carry on the business of manufacturers of plant for electric lighting, electric transmission of power, electric railways, electric tramways, electro-chemical, electro-metallurgical, and other purposes. The vendor and promoter is Mr. Thomas Parker, founder and managing director of Elwell-Parker, Limited, and for five years works director and chief engineer of the Electric Construction Corporation. The directors of the Company are Messrs. C. Tertius Mander, J.P., Thomas Graham, J.P., William Thomas, and Thomas Parker, J.P.

Engineering Trade Section.—In the annual report of the London Chamber of Commerce reference is made to the proceedings of the Engineering Trade Section. The report states that this section, at its two meetings, discussed the desirability of effecting reforms in the present Patent Law procedure, and came to the conclusion that it was not expedient to attempt to bring about any alteration in the Patent Law as at present administered. On behalf of the

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section, the council of the Chamber was requested to oppose the proposal embodied in Mr. Fenwick's Merchandise Marks Act Amendment Bill, which required the name of the manufacturer and the place of manufacture to be shown on all manufactured goods within the United Kingdom. Other subjects discussed included the Employers' Liability Bill and the discrepancy frequently found to exist between the specification and pattern in tenders for Government contracts.

Working Results of Electric Tramways.—The electric tramway constructed at Clermont-Ferrand, and which has been in operation for two or three years, was laid down by M. J. Claret, who has since transferred the line to the Compagnie des Tramways Electriques de Clermont-Ferrand. The report of this company, presented at a meeting on the 14th ult., states that the tramway legally passed into the hands of the company on December 13, 1893. The length of the line, which is served by 20 cars, is 4·34 miles, and it extends from Montferrand to Royat through Clermont, with a branch to the railway station. The number of passengers carried in 1893 was 2,492,483, the receipts amounted to £13,783, and the mileage run reached 259,062 miles. The increasing traffic has necessitated the provision of two new cars, which are to be delivered in July. The amount standing to the credit of profit and loss account was £3,875, out of which a dividend of £1 a share has been paid on the ordinary shares.

Conduit Systems in the United States.—Although the Metropolitan Traction Company would not part with the £10,000 prize it offered, it is reported that it has under consideration offers from two companies to lay down an underground conduit street railway, and that it has accepted the proposition of one of them. This is the Siemens-Halske Company, who have undertaken to put down an experimental line. The details of the system have been examined by engineers of the Traction Company, and, on the strength of their favourable report, a trial of it will be made on Lenox-avenue, where the company has recently obtained the right to lay lines upon an understanding with property owners that an underground conduit system would be used. Three miles of road altogether will be laid at the expense of the Siemens-Halske Company, and, if accepted, four miles more will be built at joint expense. The system proposed by the Siemens-Halske Company is the one that has been in use in Budapest.

The Paris Underground Electric Railway.—It appears that there is at last some hope of a definite decision being shortly arrived at concerning the projected electric railway in Paris from the Bois de Boulogne to the Bois de Vincennes. This railway, which is proposed to be carried out according to the designs of M. Berlier, who has already obtained a concession for its construction, is to form a complement of the metropolitan railway which has been discussed in Parisian circles for many years past. On Wednesday of last week, M. Jonnart, one of the French Ministers, attended before the French Railway Commission, in company with M. Colson, to furnish particulars regarding the proposed electric railway. At the same sitting the municipal engineers, councillors, and the promoter, M Berlier, gave evidence on the subject. The opinions of the General Council of the Bridges and Ways Department and of the municipal engineers was favourable to the scheme, which proposes a railway line carried in an iron tunnel 20ft. in diameter. The Chamber of Deputies is now on the point of deciding definitely on the scheme.

Niagara Falls Power Transmission.—The annual report of the Westinghouse Electric and Manufacturing Company contains the following statement: "The awarding to your company by the Cataract Construction Company of the contract for three 5,000-h.p. generators for the transmission of the power of Niagara Falls to Buffalo and other points was an event of more than ordinary importance. The officials of the Cataract Construction Company had employed the most renowned electrical engineers of the world, and had spent some years in a full investigation of the subject, and finally contracted with your company because of a belief in its ability to successfully carry out such an important undertaking. The transmission of power by means of these generators involves the use of your company's Tesla patents covering the system of multiphase motors, and therefore the successful starting of this plant cannot fail to have a great influence in the development by your company of other plants for the transmission of power from waterfalls to remote points, by reason of the experience gained in this instance, and by reason of the ownership of the controlling patents. The three generators contracted for will soon be completed and put in operation."

Measurement of Power in Three-Phase Circuits.—In discussing this subject in the columns of a German contemporary, Dr. O. Frölich deals with circuits grouped in the manner known as the link connection. If A B C are the currents in the three circuits, and P_1 P_2 P_3 the values of the absolute potential at the respective points where the power is delivered, he finds that the total power is given by the expression

$$W = A (P_1 - P_3) + B (P_2 - P_3),$$

or $$W = B (P_2 - P_1) + C (P_3 - P_1),$$

or $$W = C (P_3 - P_2) + A (P_1 - P_2).$$

If each of these three points be joined by a wire of resistance with a junction common to all, we obtain a star connection, and the sum of the currents in the three wires is zero.

$$i_\alpha + i_\beta + i_\gamma = 0.$$

Since $(i_\alpha - i_\beta)\, r = P_1 - P_2$, and similarly for the other circuits,

$$\frac{W}{r} = A\, i_\alpha + B\, i_\beta + C\, i_\gamma.$$

This formula shows how the total power is divided between the three circuits, and might be used to measure the power separately for each. For this purpose a wattmeter must be inserted in each circuit, the movable coil being traversed by the main current and the fixed coil by the current i. If the total power only has to be measured, a single instrument may be used, containing three fixed and three movable coils, the latter being, of course, fixed relatively to each other.

Union of German Electrical Engineers.—As we have already announced, the second annual meeting of the Verband der Elektrotechniker Deutschlands will be held at Leipzig on June 7, 8, and 9. The programme has now been issued. The following papers will be read: "The Scientific Electro-Chemistry of the Present Day and the Technical of the Future," by Dr. Ostwald; "Development and Position of English Electrical Engineering," by Mr. Gisbert Kapp; "The Nissl Main Telephone Exchange Switch," by Mr. F. Ross; "The Disturbances of the Physical Institute by Electric Tramways," by Dr. Budde (co-reporter with Dr. Wilhelm Kohlrausch); "The Control of Rotary-Current Plant and of Rotary-Current Direct-Current Transformers," by Mr. W. Lahmeyer; "Lead Safety Fuses," by Mr. Clarence P. Feldmann; "The Conductivity of Copper: Proposal for Introduction of a Standard System of Description," by Mr. J. Teichmüller; "Some Direct Indicating Electrical Measuring

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Instruments," by Dr. Th. Bruger; "The Pressure and Current Curves of Various Types of Alternate-Current Machines, and their Influence on the Illuminating Power of Alternate-Current Lamps," by Dr. W. Wedding and Dr. G. Rössler; "Demonstration of Some New Galvanometers," by Dr. H. Du Bois; and "Continuous-Current Machine for the Three-Wire System," by Herr von Dolivo-Dobrowolski. Among the other business of the Union is the reception of a report from the committee on the introduction of standard sizes for contacts and screws.

Electric Transmission of Power in Italy.—Signor Boselli, the Italian Minister of Agriculture, Industry, and Commerce, has brought in a Bill for the regulation of the electric transmission of power over private property, and to which reference was made in a previous issue. Clause 1 provides that every proprietor shall allow overhead and underground conductors to pass over or through his property when carried out by any person who has temporary or permanent right to use the conductors for industrial purposes. Exceptions are made to this rule for houses (but the façades in public streets are not included), and the courtyards, gardens, and lawns attached to same. Clause 2 provides that those erecting conductors on private property shall carry out the work so that there is no danger. They can also be called upon to use any appliances which may have been erected by the proprietor for such purposes, to compensate him for the use of the same, and bear a proportion of the cost of maintenance. Clause 3 provides for conductors being carried across canals, aqueducts, and other works, provided no loss is caused to the owner. By Clause 4 it is provided that where public streets, rivers and roads are crossed, or where the façades of houses are used, the special regulations of local authorities must not be infringed. By Clause 5, those desirous of carrying conductors across private property must be able to state the value and advantage of the scheme, and that the route proposed is the most suitable. Clause 6 provides that before the work is carried out, the owner of the property shall be compensated for any depreciation which would be caused to his property. By Clause 7, for any system put up for less than nine years, the property is to be restored to its original condition. Clause 8 provides that the conductors must be carried out according to existing laws and correspond to the regulations in force with respect to telegraph and telephone traffic.

Electrically-Operated Pumps.—The question of combining centrifugal pumps with electric motors is discussed by M. J. A. Montpellier in *L'Electricien* of May 19, where illustrations are given of such combinations as laid down at the Altai mines by M. L. Dumont. The author points out that by arranging the pumps, as it were, in series, it is possible to lift water to a greater height than would otherwise be the case. For instance, the delivery-pipe of a pump at one level is connected to the suction-pipe of the second pump arranged at a higher level. In this manner it is possible to lift the water to a height double that obtainable with a single pump. The lifting work would be divided equally between the two pumps, provided, of course, that their speed is the same, a difficulty which is easily overcome by the use of electric motors. M. Montpellier says that by replacing the driving pulley by means of an electric motor, the two pumps can be directly coupled to the shaft of the motor, one being arranged on each side, and the speed of each being equal. Two pumps laid down in this manner and connected in series are at work at the Altai mines, where water is being lifted a height of 67ft. The delivery of this combination at a speed of 1,300 revolutions is 600 litres per minute. The electric motor driving the pumps takes 58 amperes at 110 volts. Another combination comprises four pumps, also arranged in series, at the same mines, where the lift of water is 148ft., and the quantity 300 litres per minute. This combination is driven by a motor consuming 80½ amperes at 115 volts. The author points out that centrifugal pumps can be operated equally well with a vertical as with a horizontal shaft, an arrangement which may frequently be found useful in mines. M. Dumont has carried out an installation of this kind, where a group of centrifugal pumps placed at the necessary depth are actuated by an electric motor arranged at the mouth of the shaft, and connected to the pumps by means of a vertical shaft.

The Electrical Trades Section.—The annual report of the London Chamber of Commerce states that during the past year the Electrical Trades Section and its committees held 12 meetings. The section has again had under its consideration the regulations of the Board of Trade on overhead wires. The Board have hitherto refused to modify these regulations, on the ground that they were drafted in consultation with the Institution of Electrical Engineers, and until alterations were recommended by that body they saw no reason to depart from the attitude already taken up. The report states further that it is satisfactory to record that the Institution of Electrical Engineers has now recognised that, looking to the commercial aspects of the industry, it is absolutely necessary that these regulations should be to some extent modified, and negotiations were in progress at the end of the year which it was believed would remove the disabilities from which the industry now suffers in this respect, consistently, of course, with a due regard for the public safety. Another question considered by the section during the year was the position of the electrical industry in reference to the telephone company's monopoly of the use of earth. Recognising that this position was a serious hindrance to the development of the traction industry, the section resolved upon the appointment of an electrical traction committee, which should have power to raise funds, engage counsel, and take such other steps as might be, in the opinion of the committee, necessary for the advocacy or propagation of traction interests. This committee was in due course constituted, and presented its case before the Joint Committee of the Houses of Lords and Commons on Electrical Power, with results entirely satisfactory to the traction industry. At the close of the year the Traction Committee were in communication with the Board of Trade as to the regulations under which the industry might be carried on consistently with the recommendations in the report of the Parliamentary Joint Committee already referred to. The section also directed its attention to the National Telephone Company's Powers Bill, railway rates on electrical goods, and the desirability of the promotion of lectures on the commercial aspects of the industry during the winter months.

A Water-Pail Forge.—Raising iron and steel to a welding heat by plunging it into a bucket of water is one of the more recent electrical accomplishments which has excited no end of interest and admiration. The phenomenon was illustrated experimentally to thousands of spectators at the Columbian Exposition last year, but instead of being simply an interesting scientific demonstration, as it was there regarded, it has latterly, according to *Cassier's Magazine*, been applied in a practical way as an every-day substitute for the time-honoured forge-fire. At the Edison Illuminating Company's Pearl-street station, at Brooklyn, N.Y., the "water-pail forge," as it has been aptly named, can be seen

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in daily operation, and the practical value of its astonishing performances has there been demonstrated beyond all doubt. The apparatus there used consists in arranging across the top of an ordinary wooden water-bucket a bar of iron to which the negative pole of a dynamo is attached by a wire. The other pole of the machine is connected with a plate of copper in the bottom of the bucket. To bring the end of any desired bar of iron or steel to a welding heat, all that is necessary is to rest it against the bar across the top of the bucket and to dip the point into the water within. This closes the electric circuit, and in a few moments the end of the bar becomes hot enough to be readily worked under a blacksmith's hammer. What actually happens when the circuit is closed is this: the water in the bucket, under the action of the passing current, immediately begins to decompose into its component gases, oxygen and hydrogen, and the latter adheres in a film to the submerged part of the metal bar, protecting it from contact with the surrounding water. If now the electric current were not very strong it would cease to flow, because of the break in the circuit made by the hydrogen accumulation. With a sufficient strength of current, however, the resistance of the hydrogen envelope is overcome, and in doing this heat is developed—sufficient in this case to quickly bring the end of the bar to a white heat. That the water does not quench the bar is readily explained by the fact that the hydrogen film prevents the two from coming into actual contact. How great the possibilities of this water-pail forge are can easily be imagined. The ordinary forge and blower, and the necessarily attendant coal and smoke and dust, all are entirely dispensed with, and the whole outfit may be a likely feature of the ideal blacksmith's shop of the near future.

Electrical Sign Throwing.—In Trafalgar-square, on Saturday last, between the hours of 9 and 11 p.m., Captain Ronald A. Scott gave an exhibition of electric sign throwing by means of his patent electrical signalling projector. He selected for purposes of illustration the titles of a large number of newspapers, and when we arrived *Judy* was dancing, in letters about 6ft. long, and with an activity reminiscent of Lottie Collins, from Nelson's Column to the front of Morley's Hotel, and even flouting the sacred cupola which in an unobtrusive way relieves the stern outlines of the National Gallery. A little later we felt a guilty pleasure in seeing the *Electrical Engineer* executing a delirious fandango on the house-tops as if it had been to an Electro-Harmonic supper and found in the neighbourhood of Charing Cross the last straw which broke the back of its respectability. It was a new experience. The *Electrical Engineer* on the rampage. Inviting all London to "tread on the tail of its coat, bedad!" and conducting itself with a reckless disregard for the proprieties which was nothing less than shocking. At one moment it absorbed into itself, so to speak, the Hotel Métropole, reducing that palatial edifice to a mere hoarding for the display of its own entity. A second later and it blazed out on the front of Morley's, lit up the sombre elevation of the National Gallery, and cavorting madly the while made a probable bid for external space by soaring upwards and omitting to come down again. In these tactics it was succeeded by the *'Tiser*. We were not surprised at an exhibition of levity or of undue ambition on the part of the *'Tiser*, but when the *Morning Post* and the good old *Globe* so far forgot themselves as to urge on the same wild career, we thought it high time to step in to Messrs. Lombardi's reception-room, where Captain Scott was explaining his invention to a number of other journalists, and urge him to temper justice with mercy. Seriously, however, this method of advertising may be expected to find favour. The idea is not altogether new, but the means adopted by Captain Scott are as simple as they are effective. He uses a 15,000 c.p. to 20,000-c.p. projector of the usual pattern, fitted with a spherical reflector and cooled by a water-jacket. The designs to be thrown are in the form of stencil-plates and are placed one by one in a carrier fixed just behind the arc. Anything more striking than a poster of this kind, or the announcement of So-and-so's soap in gigantic letters of dazzling white light, it is difficult to conceive. For electioneering purposes also, Captain Scott's method should be extremely useful, while as the cost, in comparison to the result obtained, is moderate, electric sign showing will, no doubt, soon become popular among those who wish to call public attention to their wares.

The £10,000 Prize.—It appears that the competition opened by the Metropolitan Traction Company of New York for an improved system of electric traction to supersede the trolley method has turned out to be a fizzle. The following note, quoted from the New York *Electrical World*, throws some light on the matter: "In our last issue we referred to the passage of a Bill at the closing session of the Legislature on the subject of a prize for the inventor of the most economical street railway traction system. As predicted, the Bill, which has been signed by the Governor, is one authorising the State Railroad Commissioners to act as umpire in the alleged competition of the Metropolitan Traction Company. The Bill was signed on Wednesday of last week, and on Thursday the president of the Metropolitan Traction Company gave the following statement to the Press: 'Last fall we sent a letter to Messrs. Alfred C. Chapin, Michael Richard, and S. A. Beardsley, the State Railroad Commissioners, asking them to act as judges in a competition we proposed setting on foot. We offered a prize of 50,000dol. to any inventor who would offer an economical system of street railway traction which could be made available in this city, where the overhead system would not be permitted. The competition was to be open to all the world. We were flooded by letters from inventors. Between three and four thousand methods were sent us from all over. We could not wait for the Legislature to decide the question of the commissioners acting for us, however, and our offer had to be withdrawn.' In other words, several thousand American inventors were put to an expense which, in time and money, would amount to the value of the prize offered several times over by what, in the light of subsequent events, can only be denominated a sham competition. As remarked by us before, the time limit was so manifestly short that all who entered into the competition doubtless took it for granted that the company, which was presumably acting in good faith, would accord the necessary extension. The condition that the Railroad Commissioners should act as umpires was recognised by many as an impossible one in the absence of special legislation, but this was regarded, wrongly it now seems, as an oversight. The entire proceedings have an equivocal appearance, so much so, in fact, that it is probable that inventors who submitted plans will scrutinise with some interest the details of any system which the Traction Company may finally lay down. As to the Railroad Commissioners, it would be interesting to know in what light they regard the part which they have been made to play in the matter, particularly as their selection as umpires gave the appearance of good faith to the competition." Our contemporary's remarks, to say the least, are too mild for such a method of procedure on the part of the Metropolitan Traction Company.

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THE EXETER ELECTRIC LIGHT STATION.

Although the supply station at Exeter has been in operation for some time, a short description of its chief engineering features, together with illustrations, should prove interesting at the present moment. The station is situated in New North-road, belongs to the Exeter Electric Light Company, Limited, and the supply of current, which was commenced in September, 1889, has steadily increased since that date. The incandescent lighting is on the high tension alternating system, whilst the arc lighting is arranged on the series system. The boiler plant at present fixed is as follows: three Babcock and Wilcox boilers giving 150 h.p. each at 150lb. pressure; the supply of water is obtained from the city mains through a Kennedy meter, the tank being capable of storing about 7,000 gallons. The feed is effected by means of a Worthington pump through a feed-water heater supplied by Messrs. John Fowler and Co., and two injectors furnish a reserve in case of accident to the pump. The steam before reaching the engines is passed through a Boys and Cunningham separator, which effectually prevents water from being carried over into the cylinders.

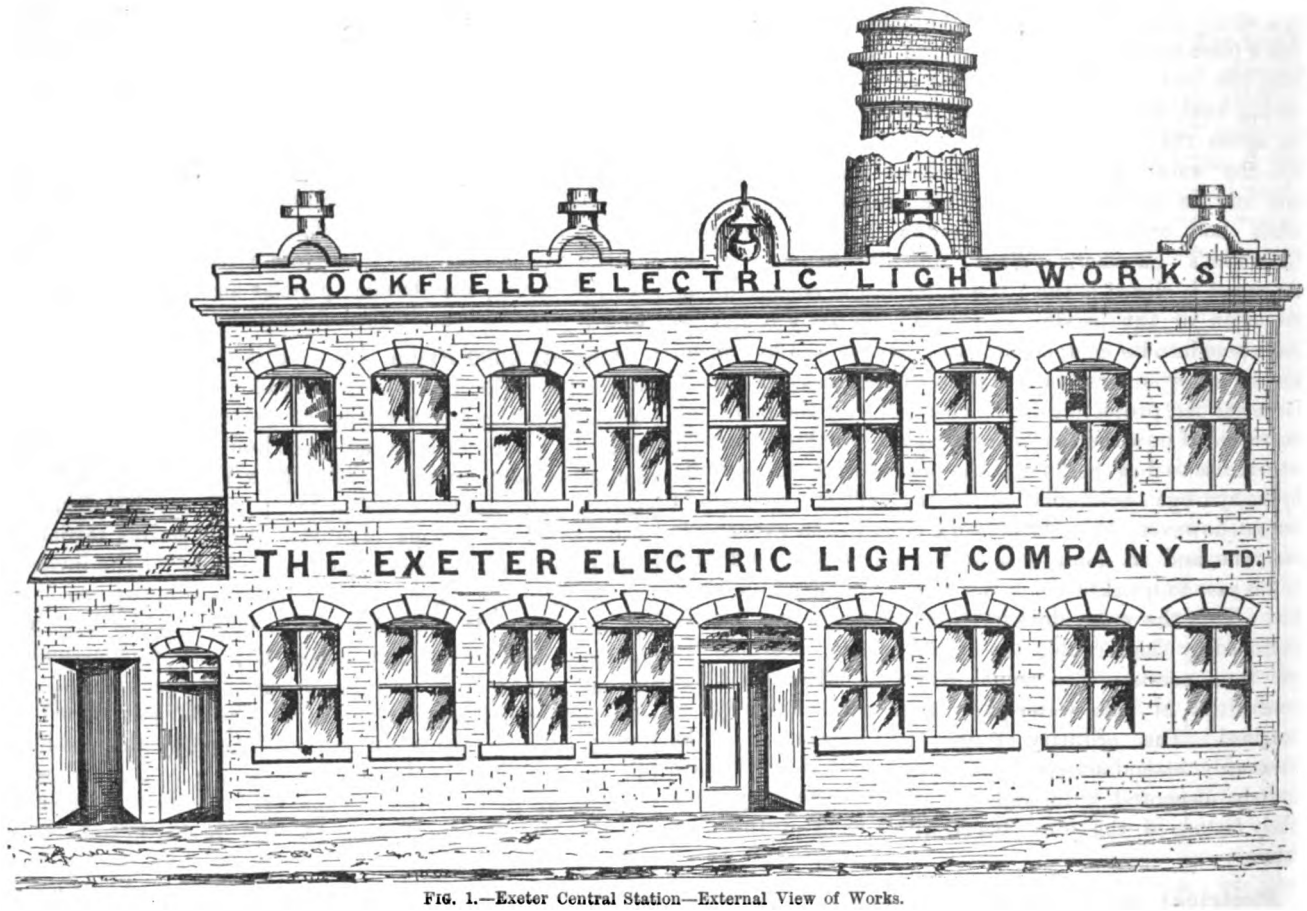

FIG. 1.—Exeter Central Station—External View of Works.

The engines comprise three horizontal compound engines by Messrs. John Fowler and Co., for the incandescent lighting; two of these are capable of developing 150 h.p. each, and the third 80 h.p. The two large engines have the high and low pressure sides on separate beds, but driving a common shaft with a flywheel between them. The small engine is on one bed with an overhung flywheel and outer bearing, and is provided with balanced valves. These engines drive by cotton ropes three Mordey

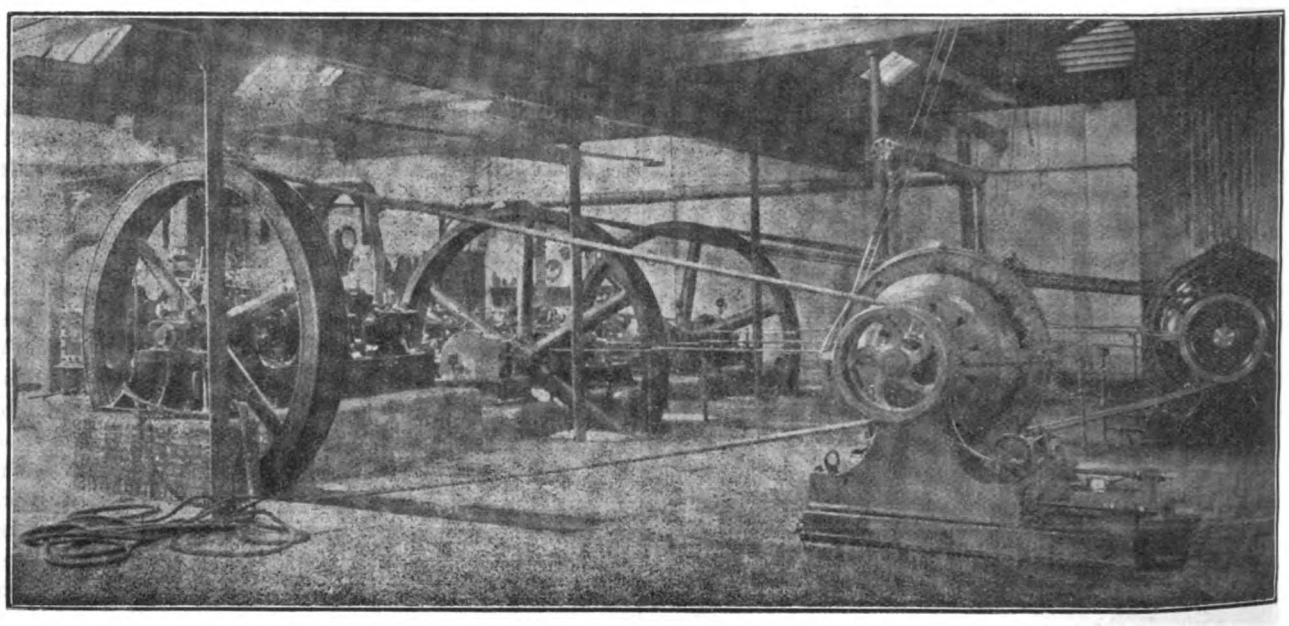

FIG. 2.—Exeter Central Station—Internal View of Dynamo and Engine-Room.

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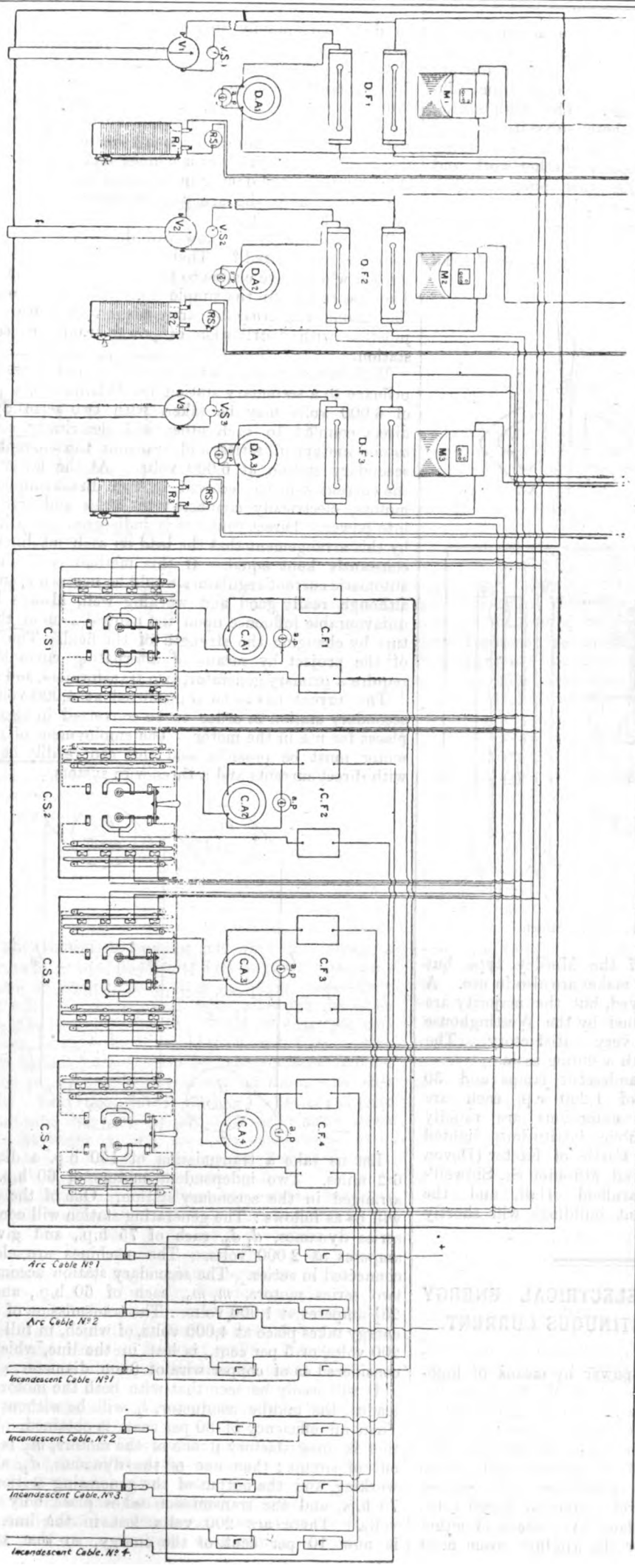

FIG. 8.—Exeter Central Station—Diagram of Dynamo, Circuit, and Test Boards.

alternators; two of the latter are of 75 units, and the other of 50 units capacity. The two larger machines have recently been fitted with new armatures of the latest type, having the two halves in parallel, with the addition of an "equaliser" to balance the output of each half. Each alternator drives its own exciter direct from its shaft by means of a claw coupling. The voltage is regulated by a resistance in the field of the exciter, which is shunt wound. This plant is used for the incandescent lighting.

There is also a series arc lighting plant, consisting of two vertical triple-expansion Westinghouse engines of the closed-in type by Messrs. Alley and McLellan, of Glasgow. These engines drive, by leather link belts, two 30-light arc dynamos of the Thomson-Houston type, supplied by Messrs. Laing, Wharton, and Down. These engines will develop 25 h.p. each at 500 revolutions, and their governing is almost perfect, especially when combined with the sensitive regulation of the Thomson-Houston controllers and regulators. A double-pole switch of special design is used to throw the load from one of these dynamos to the other.

On the switchboard each alternator is provided with double-pole long-break fuses, an Evershed ammeter, a Shallenberger meter to measure the output, a Cardew voltmeter with special transformer, and a hand regulator and switch for the exciter. The distributing or circuit switchboard was specially designed by the company s engineers, and made by Messrs. Newton, of Taunton. It comprises a main double-pole throw-over switch for each of the four main feeders, with arrangements by which any alternator may be connected independently with each circuit. These arrangements are made clear by the illustrations attached. In the diagram of the dynamo board, D F is the dynamo fuse; D A, the dynamo ammeter; *a p*, the ammeter short-circuiting plug; V, the voltmeter; *vs*, voltmeter switch; R, regulator resistance in shunt circuit of exciter; R S, regulator switch; and M, the meter. On the circuit board, C S is the circuit switch; C A, the circuit ammeter; and C F, the circuit fuse. At L on the test-board links are shown for testing purposes. The various circuits can thus be transferred from one machine to another with ease and without any perceptible variation in the light, and therefore parallel running

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has not yet been found necessary. The mains for the alternating circuits comprise four main feeders, and two series circuits are carried from the station for arc lighting. Most of the distribution is now from sub-stations with low-tension networks. The high-tension cables are led in and out of these sub-stations, and breaking devices of special design are used to shut the current off from any section for repairs or other work, and the cables can also be looped for this purpose. The feeders, mains, and service lines (about 9½ miles in length) are of the Fowler-Waring concentric lead-covered and armoured type, differing only in the amount of insulation provided. It is intended to lay about 1½ miles of fresh mains this summer.

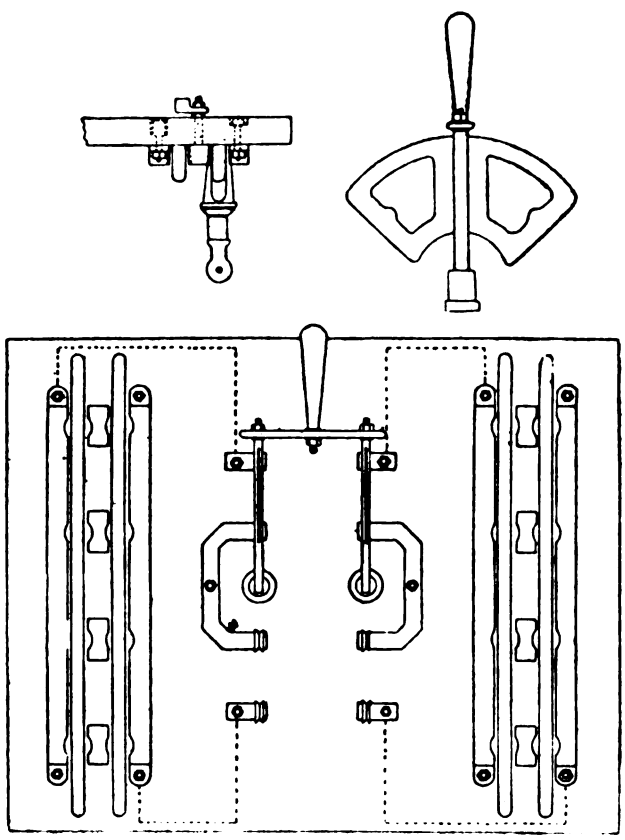


FIG. 4.—Main Double-Pole Throw-Over Switch.

The converters are mostly of the Mordey type, but "Hedgehogs" and a few of other makes are also in use. A few Thomson meters are employed, but the majority are of the Shallenberger type supplied by the Westinghouse Company, and have proved very satisfactory. The present charge is 6d. per unit with a sliding scale.

At present about 5,500 incandescent lamps and 30 Thomson-Houston arc lamps of 1,200 c.p. each are connected to the mains, and extensions are rapidly being made. Among the public institutions lighted throughout are: Theatre Royal, Castle of Exeter (Devon County Council), Albert Memorial Museum, St. Sidwell's Church and two chapels, Barnfield Hall, and the Athenæum; and other important buildings will shortly be connected.

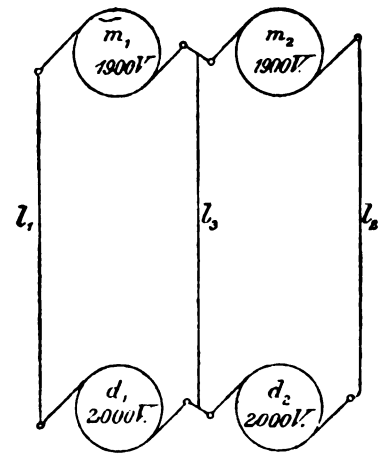
THE TRANSMISSION OF ELECTRICAL ENERGY BY HIGH-PRESSURE CONTINUOUS CURRENT.

The subject of transmitting power by means of high-tension direct currents is discussed by Mr. Ernst Schulz, of Aix-la-Chapelle, in the *Elektrotechnische Zeitschrift* of May 17. He points out that the danger of working high-tension continuous current machines and motors lies essentially in the winding of the field magnets and of the armature. Self-exciting shunt generators and motors cannot be well constructed for over a limit of 1,000 volts. By overstepping this limit the danger is present of either breaking down the shunt wire or the winding space must be disproportionately increased by the use of heavily-insulated wire. Thus from 1,000 volts we have been obliged to exclusively confine ourselves to series machines, in case preference is not given to special excitation of the shunt by low-tension current, as is necessary in the distribution of power. Both the primary and the secondary stations then contain each a small low-tension dynamo for this purpose. With series machines and specially excited shunt dynamos the danger in the shunt is avoided, although the insulation of the armature winding does not allow of exceeding 3,000 volts.

The question arises, how can direct current of 6,000 volts be transmitted? There are two cases to be considered which have claims to the execution of the scheme. The first relates to the simple transmission of power, and the second concerns the transmission of power in conjunction with distribution of power from the secondary station.

With regard to the simple transmission of power from a primary to a secondary station for distribution, a pressure of 6,000 volts may be taken with two series dynamos, direct coupled to each other and electrically connected to one another in series, and transmit the current to the secondary station at 6,000 volts. At the latter station the current will be received by two direct-coupled series motors, electrically connected in series and transformed into power. Direct coupling is indispensable, as it is only by this arrangement that the load on each machine can be constantly kept equal. If this method is not adopted, automatic current regulators would be necessary, and these, although really good and working well, always have an unfavourable influence upon the neutral zone of the armature by changing the strength of the field. The solution of the project by means of alternating currents would require a primary generator, two transformers, and a motor.

The current has to be transmitted at 4,000 volts to the secondary station in order to be converted in two distinct places for use in the motor. The employment of only one motor must be possible, and this can readily be effected with direct currents and a three-wire system.



Let us take a transmission of 150 h.p. a distance of 6·2 miles. Two independent motors of 60 h.p. will be arranged in the secondary station. One of the solutions will be as follows: The generating station will contain two series dynamos, d_1 d_2, each of 75 h.p., and giving 25½ amperes at 2,000 volts. The machines are electrically connected in series. The secondary station accommodates two series motors, m_1 m_2, each of 60 h.p., and giving 25½ amperes at 1,900 volts. The transmission of electrical energy takes place at 4,000 volts, of which, in full working, 200 volts, or 5 per cent., is lost in the line, which is here considered as of copper wire of 8mm. diameter.

It will easily be seen that with both the motors equally loaded, the middle conductor, l_3, will be without current. Then an efficiency of 80 per cent. is obtained. The position is unsatisfactory if one of the motors, m_2, is switched out of circuit; then one of the dynamos, d_2, also stops working, and the output of the generating station is only 75 h.p., and the transmission takes place only at 2,000 volts. There are 200 volts lost in the line, but this is now 10 per cent. of the energy, so that the motor

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only receives 1,800 volts and 25½ amperes, and its output amounts only to 57 h.p. Moreover, the speed of the motor diminishes, but in practice the reduction in the efficiency of the motor is so insignificant that it may be neglected.

If the transmission is effected at 6,000 volts and 17 amperes, with a loss of 300 volts, or 5 per cent., in the line, the diameter of the conductors will be reduced to 5·2mm.; whilst a four-wire system would in many cases be practicable. The author has tested a three-wire system on the lines described.

MR. BARNES ON ELECTRIC RAILROADS.

BY FRANK B. LEA.

There is no small pleasure in reading the opinions and comments of a well-informed and unprejudiced railway man upon the question of employing electric energy for locomotive purposes, and one can hardly avoid such a feeling after the perusal of Mr. Barnes's notes respecting the use of electricity in heavy railroad service, as given in abstract form in the last issue of the *Electrical Engineer*. Mr. Barnes is a well-known authority throughout the United States upon all railroad topics, and whilst, of course—like all others in his position—his training and experience have been more particularly in the direction of steam locomotive work, yet he approaches the subject of electric equipments for railways in an unbiassed manner, which offers a strong contrast to the blind prejudice too often characteristic of railway officials against any new devices or improvements made available by the progress of invention.

The mere fact that a leading railway man should bring before the meeting of a railroad officials' club some speculations upon the possibilities of electric working for the heavy service of main lines—not to speak of its actually replacing steam locomotion—is in itself enough to show a disposition to discuss the matter fairly upon its merits, and not to dismiss the whole question with a wave of the hand as a visionary madness too much in the air for sensible men to entertain for a moment.

Whilst, however, speaking thus favourably of the tone characterising Mr. Barnes's remarks, and of the final conclusions which he draws, electrical engineers must not be contented with allowing his figures to pass without question, and as though they represented the utmost, or even average, powers of electrical working in railway service. Mr. Barnes is perhaps not very far wrong in taking the average consumption of fuel in good stationary engines and in steam locomotives as being respectively 1·8lb. and 4·2lb. per horse-power hour, although the latter is by no means too high a figure. What requires pointing out, however, is that these amounts of coal consumption refer to the *indicated* horse-power in the cylinders, and not at all to the actual brake horse-power at the driving axle on the line. Yet if Mr. Barnes deducts 15 per cent. up to the dynamo terminals, and 10 per cent. for electric waste on the line, he ought at least to make some reduction in the steam-locomotive efficiency as between indicated horse-power in the cylinder and the drawbar pull.

Even the much-abused Prof. Kennedy went so far as to give the steam locomotive a drawbar efficiency of only 80 per cent. of the cylinder indicated horse-power, and in average working 20 per cent. waste in engine friction, hauling dead-weight of engine, etc., would not prove a bit too much to assume. For Mr. Barnes to take the full efficiency of indicated horse-power in the steam locomotive is therefore hardly fair to the electric motor when instituting comparisons between drawbar pulls. Moreover, the percentages of loss which he gives for an electric line are higher than is actually shown by daily working. An efficiency at the electric generator terminals of 85 per cent. of the engine indicated horse-power has been exceeded in practice for some time now, whilst the line conductor is poorly arranged indeed when the loss thereon is as much as 10 per cent. of the energy put into it. Five per cent. is nearer the mark, as the South London and Liverpool lines have practically shown. The motor loss cannot with any attempt at satisfactory results be averaged, for obviously it must vary in a great degree with the character of the line and traffic.

But even with the three alterations thus proposed in Mr. Barnes's figures, a much more favourable result is secured for electric working. In the first place, the steam locomotive burns at least 5¼lb. per horse-power hour, reduced to drawbar pull, whilst on the electric line the corresponding coal consumption should not be more than about 3lb., full load being assumed in both cases. In one of his concluding paragraphs, however, Mr. Barnes puts the whole matter very neatly, the kernel of the nut being this: "The conditions which regulate the price (of fuel) control almost entirely the saving in fuel cost incident to the use of electric motors."

If a moral is to be found, let it be the following: "Look after your coal bill, and the dividends will look after themselves."

CONTINENTAL CENTRAL STATIONS.

Some statistics were given to the Berlin Electrotechnical Society on April 24 by Mr. F. Uppenborn. These statistics, which relate to central stations, were embodied in the first annual report of the Statistical Commission of that society, and Mr. Uppenborn, on behalf of the commission, read the report to the meeting. It appears that questions were sent out and 27 replies were received from the most important electricity works in Germany and abroad. We extract the following details from the report: If the central stations are classified according to the systems in use, five groups will be found. These are (1) direct current without the employment of accumulators; (2) continuous current in conjunction with batteries; (3) alternators with transformers and without a secondary distributing system; (4) alternators with transformers and a secondary network; (5) rotary current. The stations belonging to the first group comprise those of the Berlin Electricity Works, Elberfeld, Neuhaldensleben, and Traben-Trarbach. An accumulator sub-station has recently been erected in Berlin to serve a distant district, but this need not now be considered. The stations included in this group have a high efficiency of distribution. For instance, that of the Elberfeld works, measured between the terminals of the generators to the consumers' electricity meters is almost 99 per cent., the yearly loss being only 1 per cent., whilst many German gasworks experience a loss of between 10 and 22 per cent. of the total production. The stations included in the second group are those at Altona, Barmen, Darmstadt, Düsseldorf, Gablonz, s'Gravenhage, Gummersbach, Hagen, Hamburg, Mulhouse, Stettin, Stockholm, Vienna—Mariahilf. Of these electricity works, Düsseldorf, Gablonz, Gummersbach, and Stettin have battery sub-stations. The employment of accumulators necessitates particular electrical losses, but they have a satisfactory effect upon the working of the machines, and according to statistics and reports of the managements of the electricity works, their use brings about the highest utilisation of the fuel. The best result obtained is in the case of the Altona station, where a useful work of 4·13 hectowatt-hours was obtained from one kilogramme of fuel on an average for a year. This question is to be more fully discussed in the next report. The three-wire system is most generally used in the case of direct-current stations, the only exceptions being Hamburg, Hagen, and Gummersbach. With regard to the third group, the stations at Innsbrück, and of the International Electricity Company in Vienna, belong to this. The dispensing with a secondary distributing network increases the losses, but ensures greater security against disturbances in telephone wires. The fourth group includes the works at Burghausen and at Furstenfeld-Bruck, and the fifth solely the Lauffen-Heilbronn station. It will be seen that the direct-current stations are the most numerous. It must, however, be noted that the Cologne station and two small electricity works are not included in the statistics, and as a large station on the alternating system is being erected at Frankfort-on-the-Maine, one will be able to judge of the economy of the system on the basis of working experience. A large table is then given in which the electricity

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works are grouped according to the population of the towns. The names of the towns are first given, the population and the number of lamps installed represented in hectowatts, together with detailed information.

ON THE MEASUREMENT OF THE RESISTANCE OF ELECTROLYTES.*

BY F. J. A. MCKITTRICK, PHYSICAL LABORATORY, DALHOUSIE COLLEGE, HALIFAX.

During the present session at Dalhousie College, I wished to make a series of experiments determining the electrical resistance of certain electrolytes. Not having the apparatus necessary for Kohlrausch's method at my disposal, I employed that used by Ewing and MacGregor (*Trans.* R. S. Edin., vol. xxvii., 1873, p. 51), which, according to the tests applied to it by Prof. MacGregor (*Trans.* R. S. Can., vol. viii., 1890, sec. iii., p. 49), seemed capable of giving results sufficiently accurate for my purpose.

Since this method, for its most successful application, especially if used in the way suggested by Prof. MacGregor in the latter of these two papers, requires some training of the eye in observing the motions of a spot of light, I undertook a series of preliminary experiments. In the course of these experiments, certain improvements suggested themselves to me. These improvements, and their effect on the working of the method, this paper attempts to point out.

As the above method has been fully described by Prof. MacGregor in the paper already referred to, I need give but a short sketch of it here. The electrolytic conductor is introduced by platinum electrodes as one of the arms of Wheatstone's bridge, and the process of determining its resistance is the same as in the case of a metallic conductor—viz., by a gradual adjustment of the arms. The indications of the galvanometer, however, will not be the same as in that case, owing to the fact that the electrodes become polarised through the passage of the current. The effect of this polarisation on the galvanometer is the same as if, during the passage of the current, the resistance of the electrolytic cell gradually increased.

Imagine the arms of the bridge so adjusted that, on the passage of the current, the light spot of the galvanometer moves off to the right and remains there, such a deflection having been ascertained to mean that the resistance being measured, if metallic, was too small to give zero deflection. If we gradually change the adjustment of the arms in such a way as to diminish this deflection to the right, it will not be found possible to obtain an adjustment making the deflection zero, but an adjustment will be reached with which the light spot moves first to the right, stops, moves back and off to the left, showing that though at the beginning of the flow of the current, the resistance of the cell was small enough to give a deflection to the right, it has been virtually increased by the polarisation until it is so large as to give a deflection to the left. We have thus a double deflection. As we continue changing the adjustment so as to diminish the initial deflection to the right, the double deflection will grow less and less, until finally we shall have only the deflection to the left.

If we had a magnet and mirror of indefinitely small moment of inertia, hung by a fibre offering no resistance to torsion, so that it would at any instant indicate the direction of the current flowing through it, this double deflection would only just vanish when the adjustment of the arms indicated the exact resistance of the cell—*i.e.*, when the resistance of the cell, calculated in the ordinary way from the resistances in the other arms, would be its exact resistance.

With an actual mirror and magnet of finite moment of inertia, no appreciable motion can be observed till the current has acted for some time. If the adjustment of the arms be such as to indicate a resistance for the cell only slightly greater than its real value, the first current flowing through the galvanometer will be very weak, and, before it will have had time to produce an appreciable deflection of the mirror, the electrodes will have become polarised, and our only deflection will be one to the left. If, then, we take the resistance of the cell to be that indicated when the double deflection has just vanished, we make an error, and conclude the resistance to be greater than it really is. Whether, with any magnet and mirror yet manufactured, this error can be made small enough to be neglected, can be determined only by experiment. In their experiments, Ewing and MacGregor assumed that the light mirror and magnets of Lord Kelvin's dead-beat galvanometer would give a close approximation to accurate results. In order to reduce polarisation, they used as current generator only one Grove cell, and introduced large resistances into the arms of the bridge. Their determinations, however, when compared with those given by more elaborate and accurate methods, were found to be too large, differing from Kohlrausch's, in some cases by as much as 12 per cent.

As their experiments were made when they were students and had acquired little experience in experimental work, the discrepancy may have been due to other causes than the defects of the method. Hence Prof. MacGregor, in order to test the method, made a series of experiments described in the paper cited above, comparing the resistances of solutions of zinc sulphate as given by this method and by the use of non-polarisable electrodes. To reduce polarisation he also used weak currents and, in addition, electrodes of large area. He found that if the mere vanishing of the double deflection were taken as the test of adjustment, the resistances determined would be too much greater than their real values to be regarded as a sufficiently close approximation. He noticed, however, that when he could no longer observe a double deflection, he yet could notice a distinct hesitation at the beginning of the single deflection. That this should be so is evident. For, after the double deflection has just vanished, the first current passing through the galvanometer still tends to cause a deflection to the right, but is overpowered by the polarisation current. Hence the mirror does not begin to move as soon as contact is made, but for a short time remains at rest. Clearly, then, if the adjustment of the arms be changed until we can observe not only no double deflection, but also no hesitation, we shall get more nearly accurate results. By observing the vanishing of the hesitation, Prof. MacGregor was able to get results which, in the case of high resistances, differed from their true values only by from 0·1 to 0·4 per cent.

I began, therefore, by endeavouring to observe the vanishing of this hesitation, testing my results in the same way as Prof. MacGregor had done in the paper cited above. The electrolytic cell which I used consisted of strips of window glass cemented together with marine glue. Its length was about 16cm., breadth 8cm., depth 9cm. It was divided transversely into two equal compartments by a glass partition cemented in so as to be watertight. Passing through the centre of this partition, and cemented at right angles to it, was a glass tube with its ends open. Its length was 1cm., the diameter of its bore 0·3cm. At each end of the box I placed my platinum or amalgamated zinc electrodes, as the case might be. They were each about 7cm. square, and had narrow strips projecting above the box. To these strips of the zinc electrodes thick copper wires had been soldered without the use of acid; to the platinum electrodes, thick platinum wires had been welded. By these wires the cell could be joined up as an arm of the bridge. The electrodes were, in all cases, placed as close as possible to the ends of the box. Since, however, the resistance of the column of liquid in the tube was about 1,000 times that of a cross-section 1cm. in length of the liquid in the box, slight differences in placing the electrodes made no appreciable difference in the resistance of the box. The part of the box above the surface of the liquid (especially that of the glass partition) was kept clean and dry, and during the experiments, except where the narrow strips of the electrodes projected upwards, the box was kept covered.

With this cell (1) it was the same liquid, whose resistance was measured whether the platinum or zinc electrodes were used, and (2) the tube being in the centre of a large mass of liquid, that liquid being approximately at the temperature of the laboratory, and the time intervening between two measurements—one by the platinum the other by zinc electrodes—being small, any change in the resistance

* From the *Transactions* of the Nova Scotian Institute of Science.

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due to change in temperature might be neglected. The box of resistance coils used was a small one. The coils were arranged so as to form three arms of a Wheatstone's bridge. Two of them contained two coils each, 10 and 100 Siemens units respectively. The third contained a number of coils ranging from 500 to 1 Siemens units, together with a rheochord for measuring fractions of a unit. The coils had been accurately calibrated in legal ohms by White, of Glasgow. The galvanometer used was a "dead-beat" one of Lord Kelvin's, having a resistance of 400 ohms. The mirror, with magnets attached, weighed 0·035 gramme. For making and breaking contact I used a "rocker," like that described by Ewing and MacGregor in the paper referred to above. It was so designed that the battery wire was joined up a small fraction of a second before that of the galvanometer.

I found that I was unable with any certainty to detect the vanishing of the hesitation. To my eye it did not seem to vanish even when the adjustment of the arms indicated less than the actual resistance of the cell. The motions of the magnet certainly became quicker then, but none the less did I think I could detect a hesitation. Nor is this other than we would expect. The current must always act for a certain time before any appreciable motion of the mirror occurs. The length of this time will vary with the strength of the current. With a weak current the magnet always starts slowly, while with a strong current it may seem to start almost instantaneously. With a certain current and a certain resistance of our cell, there will be a particular hesitation corresponding to the adjustment of the arms indicating the exact resistance of the cell. With considerable practice we may train the eye to recognise this particular hesitation, so that, within a short range of this resistance of the cell, we may be able to make almost perfect measurements. This was the only way in which I was able to use Prof. MacGregor's method, and the result was unsatisfactory. For when the resistance of the cell was changed to any extent, the strength of the current changed and I found that my familar hesitation was no longer that which corresponded to the adjustment of the arms indicating the resistance of the cell.

In my experiments I noticed, however, what is clearly evident, that the stronger the currents the greater was my double deflection, that if, for certain resistances of the arms, with a certain current I could get a double deflection, then with a stronger current I would get a larger deflection, and, what to me was more important, if, in the former case, the double deflection had just vanished, in the latter case it was distinctly visible. I immediately tried still stronger currents, and found that in every case the stronger the current the nearer would be the adjustment of the arms, when the double deflection had just vanished, indicate the true resistance of the cell. It appeared, therefore, that I had merely to increase the strength of the current to make my error as small as I pleased. In attempting, this, however, difficulties arose:

1. As the battery current was increased, so was the polarisation current. To lessen this, my electrodes were made as large as possible. As I have stated above, they were about 7cm. square. I might have platinised them, after the manner of Kohlrausch; but as the method under consideration, owing to the simplicity of apparatus required, is especially useful for measuring resistances of electrolytes in ordinary laboratory work, I was more interested in knowing what degree of accuracy was attainable by it with apparatus which is always at hand.

2. Since the motions of the mirror are indicated by those of the spot of light reflected from it to a screen, in proportion as the double deflection gets smaller and smaller, the difficulty in observing it gets greater and greater. Especially is this so if the current be strong, for then the motions of the spot become so rapid that, unless the double deflection is distinctly made, we are not able to observe it. This difficulty I completely removed by placing a rectangular sheet of zinc 3in. or 4in. in front of, and hiding from my eye, the left side of the screen. It was easy to place this so that, on looking past its right edge, I could just see the faintest glimmer of the spot of light. Since I always sent the current in such a direction that the double deflection was to the right, it is evident that even the least tremble of the spot to the right could be at once observed. More especially was this so, as the sheet of zinc was much nearer to the spot of light than to my eye. It is necessary, of course, that the edge of the spot of light that we are observing should be very clearly defined, and that no motion of the head should be made at the instant of observation.

3. With strong currents electrolysis of the solution goes on at a rapid rate, and, again, there is danger of the coils becoming heated. During the final measurements, then, when we are using the strongest currents, contact in the battery wire must last only for a small fraction of a second. The "rocker" thus became too slow a means of making and breaking contact. By joining up the galvanometer first and by a separate key (a method to be justified later) the solution of this difficulty became easy, for then we have only to make and break contact rapidly in the one wire. This I accomplished by slightly flattening a piece of thick copper wire, and sinking it into a board till its flattened surface was only slightly above that of the board. This wire I connected with one of the battery wires. The end of the other battery wire I flattened, and by simply drawing it over the board and across the wire, contact could be made and broken as rapidly as desired.

I found it quite impossible, as did Ewing and MacGregor, and Prof. MacGregor, to obtain platinum electrodes which in themselves did not constitute a voltaic cell. In every case my electrolytic cell was found to be a voltaic cell with a small, and, apart from polarisation, practically constant E.M.F. It is evident that with this method the adjustment of the arms which would give no double deflection would not be exactly the same as if the electrolytic cell were not behaving as a voltaic cell.

Both Ewing and MacGregor and Prof. MacGregor overcame this difficulty in this way. Call e the E.M.F. of the cell. Pass a current through the cell in such a direction as to produce a polarisation current greater than and opposite in direction to that produced by e. Then, as this polarisation slowly dies away, there will be a short time during which it will neutralise e. During that time they considered that the test could be made without error due to e.

To this procedure there are objections. In order to produce the necessary polarisation so that it will die away slowly, the current must pass for a certain time, and thus a certain amount of electrolysis goes on—the more, the stronger the current. Then there is the great difficulty in making the test at the instant at which e is exactly neutralised. In my very many trials I am not certain that I succeeded in making one test with which I was perfectly satisfied. In any case we do not entirely eliminate error due to e. For we have neutralised e only by covering our electrodes with gas, which must make the resistance of our cell appear greater than it really is. Since, however, e can always be made very small, this error is in practice negligible.

In his paper Prof. MacGregor pointed out one result of which he made no use, but which suggested to me an easier solution of this difficulty. What he showed was, in effect, that if the galvanometer wire be joined up first and the spot of light be allowed to take up a new position due to e, and if the adjustment of the arms corresponds to the exact resistance of the cell, then, on making contact in the battery wire, the current through the galvanometer due to e will remain unaltered. It seems reasonable to suppose, therefore, that if the adjustment of the arms nearly corresponds to the exact resistance of the cell, and if e be very small, then under these circumstances any change in the current due to e flowing through the galvanometer, which occurs when contact is made in the battery wire, will be very small. If, then, we should join up the galvanometer wire first, and make our measurements as if e had the value zero, would the error be negligible? To test this, I simply made several measurements, first by this method, and then be neutralising e. I varied both the size and the direction of e, but in no case was I able to notice any difference in the two measurements.

To proceed in this way, however, the galvanometer must be joined up first. Rigorously this will not give accurate results; for the principle on which measurement of resist

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ances by Wheatstone's bridge rests, requires that the current shall have attained a steady value. Whether, practically, with circuits such as I was using, any error would be introduced by this method could be decided only by experiment. To test this I simply measured the resistance of a solution of zinc sulphate, using amalgamated zinc electrodes, first joining up the battery wire before the galvanometer wire, and then *vice versâ*. The experiments that I made perfectly satisfied me that the error, if there was one at all, was clearly negligible.

During my experiments the resistance of my cell varied from 100 to 10,000 legal ohms. The accuracy with which I could determine the resistance is shown in the following table, which gives a few average results :

No. of Grove's cells used.	Resistance as determined by— Amal. Zn. electrodes.	Pt. electrodes.	Error. %
1.	6360 legal ohms	6430 legal ohms	1·1
2.	6360 ,,	6420 ,,	·94
3.	6360 ,,	6407 ,,	·74
8. Of low internal resistance	177·3 ,,	178·2 ,,	·51
,,	634·9 ,,	637·8 ,,	·46
,,	1893 ,,	1900 ,,	·37
,,	4585 ,,	4595 ,,	·22
,,	7439 ,,	7450 ,,	·15
,,	9139 ,,	9151 ,,	·13

As stated above, Prof. MacGregor's error in the measurements of high resistances varied from 0·1 to 0·4 per cent. With low resistances, however, his error was as great as 6 or 7 per cent. The first three entries of the above table show, then, that, with a comparatively weak battery as current generator, the errors in the resistances determined by employing the vanishing of the double deflection as test of adjustment, are comparatively large, considerably larger than they would be according to Prof. MacGregor's experience, if the vanishing of the hesitation were taken as the test. The last seven show that, with a strong current, the employment of the vanishing of the double deflection as test of adjustment gives results which in the case of high resistances are considerably more accurate, and in the case of low resistances very much more accurate than those given by a weak battery with the vanishing of the hesitation as test.

It would thus appear that the above modifications render this method capable of measuring all resistances with increased accuracy and low resistances with greatly increased accuracy, while they render it also capable of application without any previous training of the eye, and diminish very materially the time required for its application. The error in the measurement of high resistances is still greater than that of Kohlrausch's method—viz., 0·05 per cent. The only mirror, however, which was available for my experiments, though it weighed but 0·035 gramme, was much heavier than some which I believe are now manufactured. With a lighter mirror the inevitable error would doubtless be still further diminished.

GAS VERSUS STEAM ENGINES.

A paper was read before the recent meeting of the Incorporated Institution of Gas Engineers by Mr. Bryan Donkin on "Motors for Lighting or Generator Gas *v.* Engines with Saturated or Superheated Steam." We quote the following from the paper :

The figures contained in the following table have been taken from Prof. Witz's report, and they have been rearranged and put into the present form by the author :

Cost per Day of 10 Hours for Steam and Gas Engines with about 76 B.H.P.

(As given by Prof. Witz.)

Steam.				Gas.			
Depreciation, repairs, and interest.....	£0	13	6	Depreciation, repairs, and interest..	£0	13	6
Welsh coal, 2·6lb. per b.h.p. for 10 hours, at 23s. per ton	1	0	0	1·34lb. per b.h.p.	0	12	0
Oil and grease	0	1	3	Oil and grease	0	2	0
Driver	0	5	0	Driver	0	5	0
				Battery, etc.	0	0	4
Total.....	£1	19	9	Total..... ...	£1	12	10

But he cannot altogether agree with these figures, as, with a more economical steam-engine of the best type, only 1¼lb. of best coal per brake horse-power would be sufficient at a moderate speed and steam pressure, or a difference for 10 hours' work of 6s. 11d. per day in favour of gas, or, say, £100 a year taking 300 days. This is the calculated saving for these particular motors, exclusive of getting up steam or gas, and during gas trials at constant full load.

With this latter consumption the cost per day with steam and gas would be about the same. But then it may be said that the best large modern gas-engines, with generator gas, would only require about 1lb. to 1¼lb. of good fuel; so that the above proportion would not probably be altered materially. Much will depend on the price of fuel in the particular town under consideration. Mr. Dowson has done much, and was the first to make and introduce cheap generator gas, and to bring its advantages well before the public. He has written several excellent papers comparing steam and gas engines. A few extracts from trials, etc., from his last paper at the Institution of Civil Engineers are here given. According to Mr. Dowson, gas-engines for electric lighting, developing about 7,000 h.p., have been sold in England, and "Otto" engines for 11,000 h.p. in Germany. Doubtless the majority of these work with town gas. Messrs. Crossley say the number of "Otto" gas-engines in use in England is now about 20,000, and we may assume, perhaps, nearly double this number for all kinds of gas-engines. To give the best economy, a gas-engine should be worked at full load. There are no high-power gas-engines for electric supply stations yet working in England or in large cities on the Continent, all the existing central stations using steam. In London, mostly quickly-running compound and triple Willans engines are employed; but there are also other types, chiefly non-condensing. Mr. Dowson advocates the use of gas motors and generator gas instead of steam for central electric stations. A Dowson gas-generator usually consists of a small steam-boiler giving superheated steam, a generator, a cooler, a sawdust scrubber, and a holder. The gas passes through water twice, and finally through the coke and sawdust. For an 80-b.h.p. plant, the cost erected is about £325; for 530 h.p., about £1,100. At "Chateau Say," with 650 incandescent lamps, an "Otto" engine, with Dowson gas, consumed 1·2lb. of fuel per indicated horse-power hour. At the Chelsea Flour Mill, a 60 nominal horse-power twin-cylinder gas motor, with Dowson gas, 17in. diameter and 2ft. stroke, going at 156 revolutions, and giving 118 i.h.p., has been about two years at work. The amount of anthracite and coke used during a constant full load test was about 0·87lb. per indicated horse-power per hour. The governing is said to be satisfactory, and the cost of wages and lubrication is about the same as with a steam-engine. The gas consumption is 63ft. per indicated horse-power per hour.

The following is taken from the recent and very interesting Howard lectures of Prof. W. C. Unwin, F.R.S., at the Society of Arts, on the "Development and Transmission of Power": Many of the disadvantages of solid fuel are diminished by employing coal to produce gas, and using it in internal furnaces or gas-engines. Gas motors work with a higher thermal efficiency than steam-engines. The cost of ordinary lighting gas is increased, both by the need of a large generating plant to meet the great fluctuations in the demand for lighting and heating, and by the large distributing charge involved in supplying a great number of small consumers. If gas were made especially for heating and power purposes, either coal, water, or producer gas could probably be distributed to power users at less than half the present price of coal gas. From test trials made on a large pumping-engine of the London Hydraulic Power Company, the consumption was 2·2lb. of coal per indicated horse-power hour, but in ordinary intermittent work it is one-third more. This includes keeping the boilers hot, getting up steam, stoppages and starting of the engine, and with very different loads by day and by night.

Prof. Kennedy says that, at half load, the consumption with gas or steam engines per brake horse-power hour is about 40 per cent. more than at full load. It was mainly here that the loss in the engine due to "load-factor" comes in. A steam-boiler does its best at half to three-quarter

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power; and at quarter power it works very wastefully. When a boiler is only kept hot, but not supplying steam, it may be called the "stand-by" loss. The professor adds that, from his experiments with boilers, by shutting down the stop-valve, he reduced this loss to 10 per cent.; or the consumption of fuel in a boiler not making steam was about 10 per cent. of the whole consumption. In case of fog, in electric stations or in large gas-works, it is often necessary to keep up steam, so as to be ready for an engine start at any moment. Prof. Kennedy uses in the electric supply stations under his charge non-condensing engines, giving on test trials 24lb. of steam per electric horse-power = 32lb. of steam per unit. His boilers give 11lb. of steam per pound of good coal, and 9⅓lb. reach the engine during a test. This works out to 3·4lb. of coal per electric unit delivered on a test. Instead of this, the actual figures for three to four weeks gave 5·3lb. This important difference between a test trial and several weeks' run is due to all losses at the station; keeping boilers and pipes under steam, and engines running at different loads, etc. As to a saving, by improving the engine load-factor a gas-engine would not, he considers, help at all. Such an engine has exactly the same drawbacks as a steam-engine in this respect; and more information is needed as to losses in a gas-generator over several weeks, corresponding with the losses in the steam-boilers mentioned.

The author has lately made some experiments with Mr. C. C. Carpenter on a compound horizontal condensing steam-engine at the Vauxhall works of the South Metropolitan Gas Company, using saturated steam. Six trials were made—three with, and three without, steam in the jackets. The results of these experiments gave from 12 to 16 per cent. gain due to the jackets in use. With 60lb. pressure in the boiler, and with all the jackets in use, 19⅓lb. of steam per indicated horse-power hour were consumed. The Cornish boiler used gave an evaporation of 8lb. to 10lb. of dry broken coke from a temperature of feed-water of 212deg. F. Dry coke per indicated horse-power hour, 2·5lb.; coke per brake horse-power hour, 2·7lb. Taking the price of coke at 1s. 1d. per cwt., this will give 0·3d. per brake horse-power per hour. The indicated horse-power varied from 43 to 63 in different tests, but the load was kept fairly constant during each eight hours' run. The thermal efficiency of the engine, with 60lb. steam and all jackets on, was 12½ per cent. The boiler efficiency varied from 63 to 79 per cent., according to the method of stoking. The boiler was not forced. The calorimetric value of 1lb. of gas coke varied from 12lb. to 13lb. from 210deg. F. per cent.; ash and clinker in coke, 9 to 14 per cent. The priming of the boiler was under 0·5 per cent., or practically nil. Mr. Holgate gives the following figures as to the first cost of steam and gas motors for an electric plant of 1,160 i.h.p. for 10,000 incandescent lamps: area available, 880 square yards; steam—five 160-h.p. boilers, six steam-engines, six dynamos, ropes, etc., £18,365; gas—Dowson generator plant, 11 gas-engines, 11 dynamos, belts, etc., £16,500.

INSTITUTION OF ELECTRICAL ENGINEERS, May 24.

Mr. ALEX. SIEMENS, President, in the chair.

At last night's meeting of the Institution the following candidates were balloted for:

Member.—Nathaniel Shepard Keith, 6, Queen-street-place, London, E.C.

Associates.—Arthur Barrett, 18, Park-side, Cambridge; Walter Eccles, Medina, Putney, S.W.; Charles J. Garnett, Keighley Electrical Engineering Company, Keighley; Percy Huddleston, 21, Upton Park-road, Chiswick, W.; G. C. F. Székács, Avalon, Eastbourne.

Students.—Alfred Howard Gossage, Faraday House, Charing Cross-road, W.C.; Alfred Lovell Phillips, 16, Peak Hill-gardens, Sydenham, S.E.; Charles Stirling, King's College, Strand, London; Howard Stanley West, Faraday House, Charing Cross-road, W.C.; Leopold A. S. Wood, 74, Cheapside, E.C.

The discussion on Mr. Crompton's paper, on "The Cost of Electrical Energy," was resumed.

Mr. Segundo said the public did not care how many watts were used in their lamps, what concerned them being merely to get a good light. He thought that there was not much room for improvement in boilers, engines, and dynamos, but improvements could be effected in the methods of distributing electricity, and especially in lamps. If the incandescent lamp could be improved so as to give one candle-power for 2·5 watts it would bring the price of electricity towards that of gas.

Mr. Shoolbred referred to the question of water-tube boilers, and could not agree with Mr. Crompton's theory that Lancashire boilers gave worse results. The cooling down of the system of network in water-tube boilers caused losses. With regard to the question of accumulators, he produced diagrams of the working of the station of the Bradford Corporation, which showed that considerable economy resulted from their use. Mr. Geipel, speaking of the proportion of capital to the units sold, had said that Mr. Crompton's figure of 2s. was almost impossible. However, at Bradford, the proportion had been 2s. 6d., and he considered that 2s. might certainly be reached before long.

Mr. Henwood said no method for the complete combustion of coal had been found. Hand shovelling was uneconomical, and the mechanical stoker was more wasteful. Moreover, the heat imparted to the fire-bars was a great loss. It paid best to use fuel of the highest calorific value. An internally-fired boiler was to be preferred to any other. To use coal with oil-fuel was a mistake. He had been able by reliable tests with oil-firing to obtain three times the evaporation of coal. He gave a brief description of the Petersen water-tube boiler, from which excellent results were claimed.

Mr. Dykes read a letter from Mr. Tonge, the engineer of the Preston Company, who sent a table of the cost of generation and distribution per unit delivered to customers by the Preston Electric Light Station. The figures were: January-June, 1893, total cost 3·42d.; July-December, 1893, 3·82d.; January to March, 1894, 2·710d. The station was exceptional in Mr. Crompton's list, as it was the only low-tension station where double-acting engines were in use, and Mr. Crompton had discarded them as abnormal. However, it would be seen that all the items showed a downward tendency, except coal, which was erratic, and had been affected greatly by the coal strike, the price in the locality having doubled. Mr. Crompton had not allowed for this. The efficiency of the distribution had been given by Mr. Crompton as 80 per cent., but Mr. Tonge made it more. The efficiency of the dynamos was 83 per cent., and as the sets were of only 100 h.p., this compared favourably with other results. The coal consumption per unit sold was 29lb., small slack being burned in Lancashire boilers. The best result they had obtained was 17½lb. of coal.

Prof. Unwin stated that Mr. Crompton's paper showed how much mechanical energy had to do with the financial results of central stations. He differed from the author as to Welsh coal being more valuable than north country coal, the only advantage of the former being its smokelessness. Three tests had been carried out, which showed 10lbs. evaporation per lb. of coal; two of these tests were made with northern coal and one with Welsh, showing them to be equal. Mr. Crompton had made strong assertions about the Lancashire boiler, which he virtually described as only half a boiler, it not being a whole one till an economiser was added. He had, however, made tests with a Lancashire boiler without an economiser, and obtained 11·78lb. evaporation. The Babcock was a good boiler, but he was doubtful about its being forced beyond its rated power. He thought that if the actual heating surface were taken into consideration, the results would prove not very great. Long-stroke slow-speed engines had up to now given the most economical results. Mr. Crompton had laid down a formula for central stations, which ran: "Welsh coal, Babcock boilers, high speed, short stroke, direct coupling." This, however, was not the only good formula available; and the speaker thought such formulæ mischievous. Prof. Unwin concluded by considering the question of the superheating of steam.

Mr. Peach referred to the Economic boiler, an important feature of which was the combustion-chamber at the back. The table No. 3 given by the author was valuable to central-station engineers, but it was of less value for a comparison of boilers. One of the most important points in the selection of boilers was the cost of maintenance and repairs.

Prof. Kennedy, in reference to coal consumption, mentioned that at Eccleston-place station, it had been got down to 4¼lb. per unit generated during the first three months of the year. The author had perhaps put the matter a little too far out of the scale. They might make a more possible ideal, the details of which he entered into, and get 3·46lb. of coal per unit sold. Prof. Unwin had referred to the question of evaporation in the case of north country coal. He (the speaker) would modify the former's statement; it was more difficult to get the value out, although with proper care it could be got out. At Glasgow a kind of tar from the gasworks was used in connection with the marine type of boilers, and it answered well. Concerning Lancashire boilers, tests made at Easton and Anderson's yielded an evaporation of 11·71lb. per pound of carbon value, whilst 12·4lb. had been attained—that was a high result. He believed such boilers could be made as economically as any others if they received proper treatment. In dealing with rope *versus* direct driving, he mentioned that a series of tests were now being conducted in Belgium, and that when the results were published they would prove of great value. As to obscure losses, tests at the Millbank station showed that those losses reached as much as 7 per cent. of the steam during a 24 hours' experiment.

Mr. Halpin and **Mr. Rosenthal** having gone into details concerning boilers,

Mr. Crompton replied to the discussion, and the proceedings of the last meeting of the present session were brought to a close.

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THE
ELECTRICAL ENGINEER.

Published every Friday.
rice Threepence; Post Free, Threepence Halfpenny.
Editorial and Publishing Offices:
139-140, SALISBURY COURT, FLEET STREET, LONDON, E.C.

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TO CORRESPONDENTS.

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All communications intended for the Editor should be addressed C. H. W. BIGGS, *139-140, Salisbury Court, Fleet Street, London, E.C. Anonymous communications will not be noticed.*

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E.C.C. v. THOMAS PARKER, LIMITED.

We have received a letter from the E.C. Company in common, we suppose, with most other technical papers. We propose to give the subject-matter of this letter a little more prominence than it perhaps deserves, but it allows us to air a grievance which no doubt we have previously referred to, and most probably shall have to refer to again. Of course the first, and perhaps the last, thought of readers will be that technical papers are somewhat put out because they do not obtain patronage—that is, they do not get advertisements. That may be so. It is but a human feeling, after all, yet against this idea we protest. We desire patronage and support as much as anybody, but we would see the best man alive at the other side of the universe before we would condescend either to speak or to remain silent at his desire. We have before said, and we say it again, that two at least of the electrical journals are controlled, body and soul, by men interested in companies, and that these journals dare not say booh to any of a number of particular geese. If the public think they get independent criticism from either of these sources, they are mightily mistaken. Thomas Parker, Limited, has just applied to the public for money. It is usual when such application is made to supply the technical journals with a prospectus of the company; such observance, as far as we are concerned, has been in this case honoured in the breach. The formation of electrical companies at the present day is no longer a purely financial matter—that is, a mere matter of floating one more set of speculative shares for Stock Exchange purposes. Companies now floated have a substratum, more or less, of actual intention to do work and earn dividends. Technical journals probably know better than any other quarter the prospects of a new departure, and investors would do well to insist that promoters give them the opportunity of speaking. It is impossible to speak if the materials for criticism are not forthcoming, and we do not think it would be wise to enter into details upon a mere advertisement, which may or may not be a complete statement of matters as they stand. Although we think Thomas Parker, Limited, would have been better advised to have taken the Press more into confidence, we have no hesitation in going further and speaking in stronger terms of those who have rushed to get letters into the papers, mainly, we suspect, to secure good and gratuitous advertisements. Just let us examine this question—never mind for the moment about gratuitous advertisement; the people whom we mention are heartily welcome to all they get. According to the *Times*, "Thomas Parker, Limited," says "The vendor has acquired and will assign to the company the Eickemeyer patents for winding." The whole paragraph reeks of "winding"; and upon this the managing director of the Otis Elevator Company rushes into print about something totally irrelevant: but the opportunity is good, and he gets his advertisement. We also think that the E.C. Company has gone out of its way to ask the unbiassed and uncontrolled technical Press to advertise its objections to the prospectus of Thomas Parker, Limited. We have

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not to provide any evidence of "good faith." We have published no prospectus which may contain libellous matter or incorrect statements; then why should we be asked to gratuitously advertise the contradictions? Some companies must think the technical Press a medium to command. They would be like the centurion—say, Do this and Do that, and expect it done without demur or question. When they, through directors or solicitors, control the paper, no doubt it is done, but not otherwise. If the E.C. Company object to anything stated in the Thomas Parker, Limited, prospectus, their remedy is simple, though it may be costly. It is cheaper, however, to get every paper to insert these contradictory or misleading statements, and so to make the public feel a little undecided as to the advisability of dealing with a new firm, than it is to prove the prospectus contains anything illegal, or even morally incorrect. Though two blacks never make a white, we might suggest that in connection with the formation of the E.C. Company itself there is a good deal of information we should even now like to obtain. Did the public ever know—does it know now—how heavily the company was handicapped through the grasping action of the promoters? Who were those promoters, and what was the amount of promotion-money they received? But to return to the E.C. Company's letter—it is very indefinite, except one point—namely, that the prospectus conceals a fact—the real position of the "Eickemeyer" patents. Now, unless we are misinformed, this definite statement is absolutely disputed, and in a telegram to the *Pall Mall Gazette* we have a distinct statement that "Thomas Parker, Limited, are the entire owners for the United Kingdom of the Eickemeyer patents for winding dynamos." The question of the position of the Eickemeyer patents is not exactly new, and it is admittedly under dispute, but that question is a question for the lawyers to decide, and certainly not one which we or the general body politic can decide. What does this move of the E.C. Company mean? Are they desirous of protecting the public? If so, their action comes too late. Are they desirous of counteracting the competition of a strong trade rival in the cheapest manner? If so, they will not succeed. Other paragraphs of this letter are altogether indefinite. One points to a "misleading statement," another to a "reason to believe that we shall have to," though the next states definitely that the matter has been placed "in the hands of our solicitors." That information is no doubt interesting, but not to us. We are not particularly anxious to know that the lawyers are to have another fight, or that there will be another long legal bill to pay. We have our own opinion on these matters, and though by no means addicted to that pleasant and profitable game so well known and followed in America, we do understand that even here bluffing is not always unremunerative. There is, however, always a consolation to those who bark, even if they cannot bite, that a statement made twenty-four hours in advance of the contradiction can never be fully overtaken. Hence it often pays to challenge and then run away.

REFUSE DESTRUCTORS.

The publication of Mr. C. Jones's (Ealing) book on this subject will no doubt direct the attention of local authorities and consulting engineers once more to the question of the utilisation of the waste heat obtained from this source. We have always held that there is refuse and refuse; that in certain districts, under ordinary circumstances, a vast amount of waste heat may be economically utilised; but in other places there will not be, except at irregular intervals, any waste heat to utilise. So far as the electrical engineer is concerned, he can point out how, when, and where the waste heat required can be obtained, and in approximately correct quantities. His examination, however, of the problem is usually from a different standpoint to that of the sanitary engineer. The latter will probably consider sanitary matters only. He has certain refuse to get rid of, and gets rid of it. If there is any waste heat he utilises it, but he does not start upon his design with the intention of getting waste heat. His intention is to destroy noxious matter. Thus in many cases all the heat generated will be required for the immediate object in view. Probably Prof. Forbes, in his investigation of the subject, took one of the very best districts possible to show what might be accomplished with dust-bin refuse, and we have no hesitation in saying there are numbers of districts wherein the required artificial light for the houses might be provided by the destruction of the dust-bin refuse by fire. On the other hand, there are other districts where this would be impossible. Mr. Jones has incorporated in the book we refer to a chapter by Mr. Tomlinson upon this question of power production. There is nothing new in what Mr. Tomlinson says. He only summarises various reports and papers, most of which have been given in this paper when read or published. One important point no doubt will in the near future be thrashed out by municipal engineers who are answerable for the sanitation of our towns. Is it possible to destroy dust-bin refuse such as examined by Prof. Forbes in one way, and refuse of other kinds in other ways? By so differentiating the refuse, they might do much to provide the artificial light publicly required, relieving the municipal bills in that way, though it is possible the getting rid of the other refuse might give an adverse balance to the accounts; in other words, it may prove more economical for authorities to use the best refuse to get rid of the worst, rather than to use the best refuse to obtain light and getting rid of the worst in another way.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

GAS UNDERTAKINGS IN RELATION TO THE USE OF GAS-ENGINES.

SIR,—After a lapse of nearly a year Mr. Lees has reverted to a paper of mine read before the Gas Institute at Belfast, and has endeavoured to show that I understated the number of gas-engines used in gasworks.

What I said was: "I believe there are about 1,600 gas-

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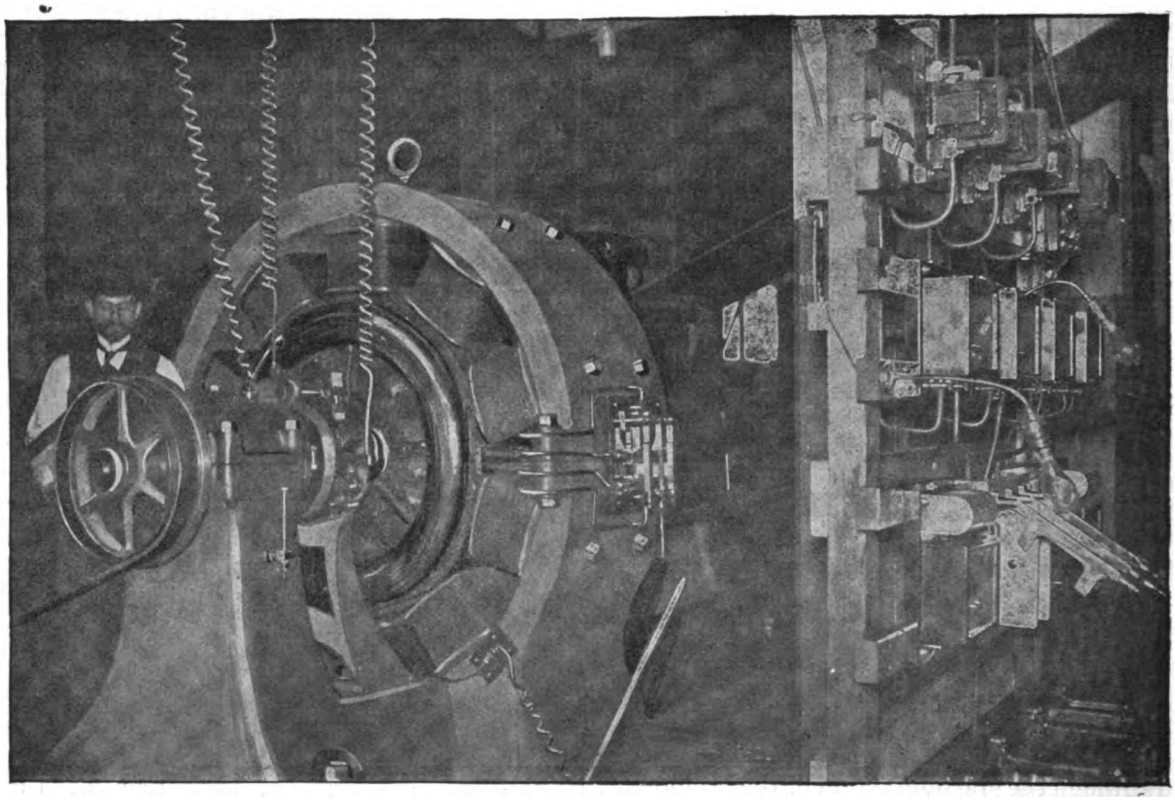

FIG. 3.—Synchronous Motor and its Switchboard.

works in the United Kingdom, but gas-engines are used at only 200 of them. In most cases these engines are of 4 h.p. nominal and under—several being of ½ h.p. and some less. There are only seven of 12 h.p., but five of 16 h.p., and none of larger size."

I may be wrong as to the number of gas-works in the United Kingdom, but as to the 200 engines in use a year ago, I beg to say that before writing my paper I wrote to all the leading makers of gas-engines, and they were good enough to give me particulars of all engines sold for gasworks. The figure 200 is based on this information, and if Mr. Lees will enquire more closely than he appears to have done, I think he will find that his opinion, not mine, "has been formed on insufficient evidence."—Yours, etc.,

May 21, 1894. J. EMERSON DOWSON.

THE THREE-PHASE TRANSMISSION PLANT AT TAFTVILLE, CONN.

In our last issue we gave a description of this plant, which has been put down by the General Electric Company of the United States. By the courtesy of the company, we are now enabled to give the annexed illustrations showing the application of the system. Fig. 1 is a plan of the power plant in the basement of the mill; Fig. 2 shows the main switchboard; and Fig. 3 the synchronous motor and its switchboard.

Electric Locomotives in France.—The Paris-Lyons-Mediterranean Railway Company are having three types of locomotives built, of which 40 compound steam locomotives of one type will be constructed. A second type is electric locomotives, in which the electric motor is installed on the rolling-stock, and the third type, it is reported, comprises 60 electric locomotives, each able to haul 800 tons at 15 miles an hour.

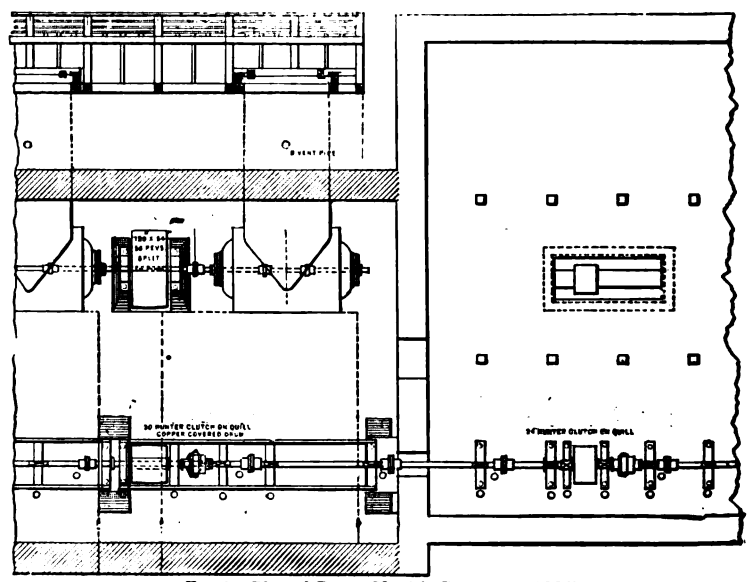

FIG. 1.—Plan of Power Plant in Basement of Mill.

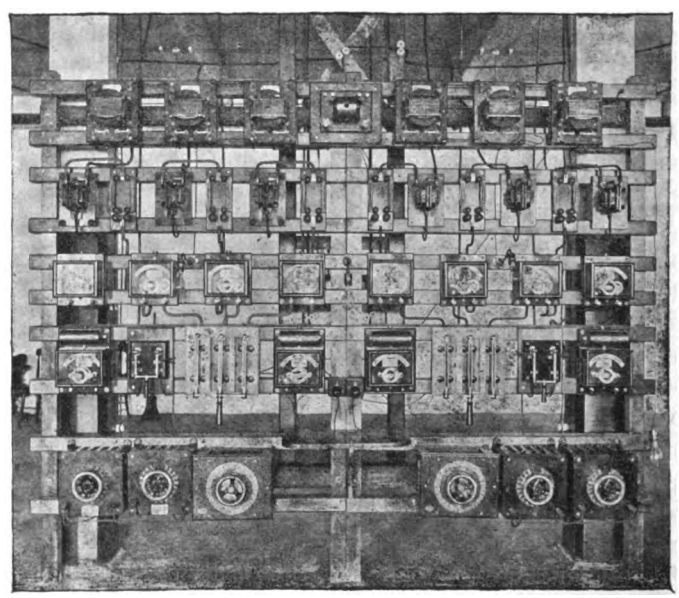

FIG. 2.—The Main Switchboard.

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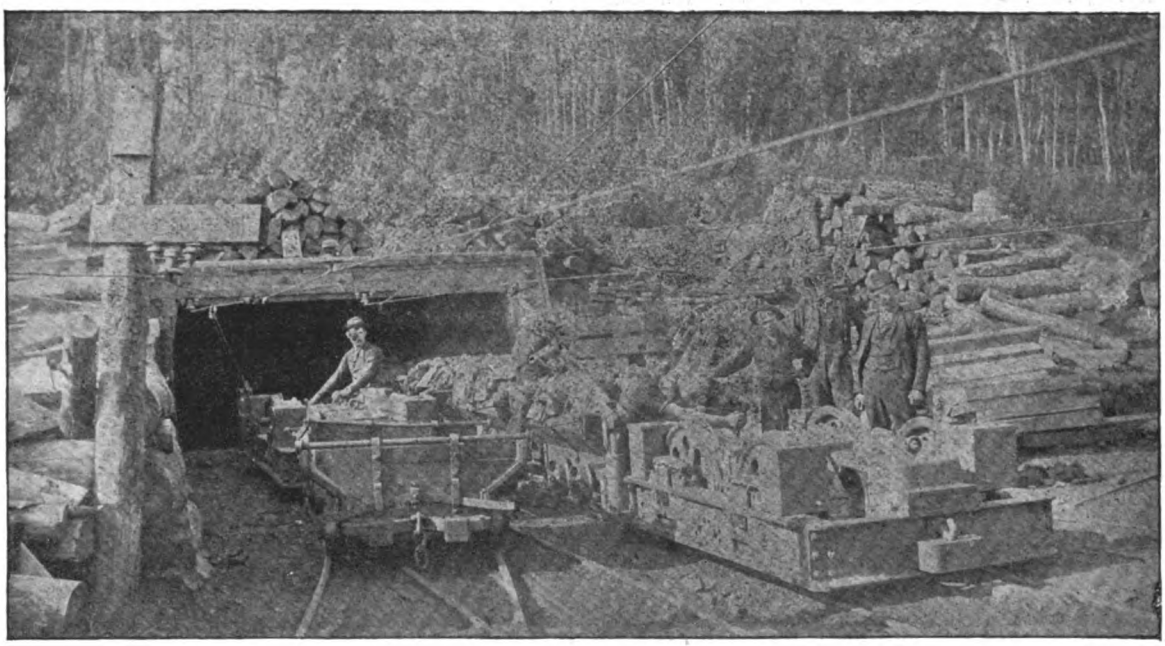
ELECTRIC HAULAGE IN MINES.

Concrete examples of the adoption of electricity to the exclusion of all older methods are generally more convincing in their import to the public mind than mere hearsay or description. The accompanying illustration shows a striking example of the supercession of older haulage methods by the electric mine locomotive in an important coal mine in Pennsylvania. The mine in question is the Rear Run Mine of the Blossburg Coal Company, near Landrus, Tioga County. The locomotives, of which there are two, are of the T.M.M. type—that is, "two-motor mining" type—each of 30 h.p., manufactured by the General Electric Company, of the United States. They are propelled by two W.P. 30 motors, one being geared to each axle. Current is brought to the motors by a specially designed trolley arm, on which the trolley wheel is swivelled to permit of its adjustment to the various irregularities of the wire line. The trolley arm can be set in sockets on either side of the locomotive, which may thus be run into headings on either side of the main haulage way, which is lighted by incandescent lamps placed at the entrance to each cross-head 100 yards apart. The dimensions of the machines are: horse-power, 30; speed, six miles per hour; draw-bar pull, 1,500lb.; gauge, 36in.; wheel base, 30in.; diameter of wheels, 28in.; width over all, 48in.; length over all, 9ft. 6in.; height above rail, 31in.; weight, 7,500lb. The current is furnished by a General Electric D. 62, 75-h.p. generator, driven by a Harrisburg Ideal 80-h.p. engine. The maximum load which these locomotives have been called upon to handle is 32 loaded mine wagons, each weighing 3,200lb., and the way is one part a 3 per cent. grade. The daily haul of the locomotives is about 650 tons. The entire plant has been pronounced eminently satisfactory, the locomotives having shown capabilities beyond the specification or the General Company's guarantee. Their presence in the mine has done away with the slow-going limited mule, and induced great economy. The small height of the machines above the rail level allows them to run into places impossible to any mule, and their ease of control and operation is such as to render them invaluable.



A NEW CONDUIT SYSTEM OF ELECTRIC TRACTION.

Our New York contemporaries describe the Johnson-Lundell conduit electric railway system, of which an experimental line has been laid down at East Sixty-nine-street and First-avenue, New York City. The track runs around a whole city block, with stiffish grades and difficult curves of necessarily short radius. The power-house is at the foot of the hill and at the centre of that section of the track or circuit. The generating plant comprises a vertical engine driving directly a pair of Lundell dynamos, the unit being such that it could be enlarged on exactly the same proportions up to any size for any road. The New York *Electrical Review* states that, by means of the interior conduit telescopic iron tube, current is carried to the track at the proper points of feeding, and is distributed without any loss due to leakage or conduction, owing to the high insulation of the ducts. The track itself is of ordinary construction as to the rails. Between the rails it is asphalted or paved. Examples of both are shown, and paralleling the rails lies a conducting bar or strip of metal embedded in the asphalte. This bar is level with the surface, and is divided up into sections, with insulating blocks of stone or other material between them. Just outside the single track, or midway between the double tracks, are plain boxes with iron covers flush with the street surface. In these boxes are substantial electro-magnetic devices which deliver current to each section as the car comes along, and then lie quiet until the succeeding car rolls up. These switch-boxes are water-tight, and may be compared to automatic switchmen. Each box governs its particular sections of track. The car carries a pick-up rubbing brush, which leads the current into the motor, and which takes the place, or fulfils the function, of the trolley pole wheel. There is one great difference, however, which the eye does not reveal. The trolley system is alive throughout. This is not alive anywhere except at the point over which the car is passing. The difference of potential between the two sides of the circuit between which the car moves is practically and actually nil.

The car has but one motor, which is central under the car, and drives on each axle by means of bevel gear, and with sprocket wheels and link chain in flexible connection. Its suspension is flexible, the bevels are boxed, the sprocket wheels and links mesh noiselessly; and thanks to the intervention of a bipartite screw coil in close relation to the armature shaft, the motor, though capable of instantaneous arrest or sudden starting, never moves off or stops with a jerk. The motor is iron-cased and protected against dirt, stones, moisture, etc. Underneath the car is a steel brush which gathers up the current and passes it up into the motor, the return being, as usual, through the rails; the conducting strip between them is only alive when a car is right over it. Under the seats are frames holding a very simple, elementary form of lead storage battery, enough to furnish the voltage at which the motor runs—300 volts—and, though with very few plates in each cell, giving considerable capacity. The batteries are always in place; they need no change, practically no attention, but

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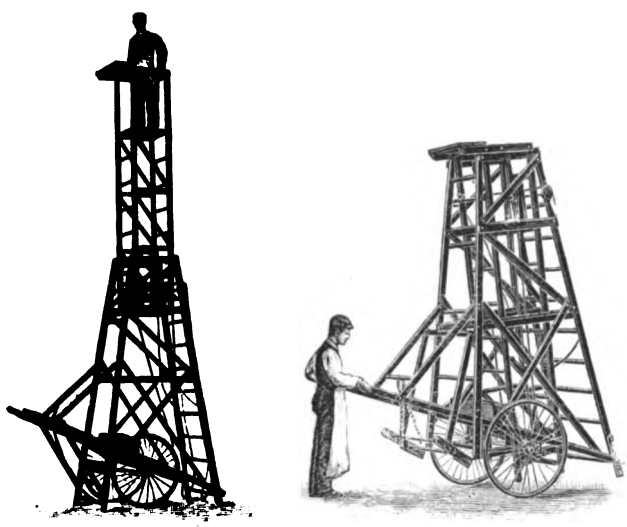
at a moment's notice they furnish current and carry the car through many emergencies. The batteries play one or two parts in the internal economy of the car, "picking up the circuit" for a second when it starts; lighting the car; but their great beauty is that they render the car at once self-contained and dispense with the usual costly complicated and troublesome wiring at crossings, switches, steam-railway tracks, etc. If the car has not sufficient headway to run over a crossing, the battery will do that, just as it will keep the car going should it be deprived of central-station current, or even put on a line that is without electricity. The advantages claimed for the Johnson-Lundell system are absolute and immediate control of the car, moderate first cost, low rate of depreciation, independence of weather conditions, moderate cost of operation, independence of each car, freedom from noise, and ease of adaptation and extension.

STREET LADDERS FOR ARC LAMPS.

The annexed illustrations show a telescopic ladder tower, which has just been supplied to the National Electric Supply Company, at Preston, for a man to wheel about the roadways to attend to street arc lamps. The wheels are of the heavy cycle pattern, with spring wired rubber tyres, 40in. diameter. The base is 6ft. by 3ft. 6in. when closed, 10ft. 6in. high, and a platform in the sliding section, 2ft. by 1ft. 9in., enables the trimmer to reach



25ft., at the same time being surrounded by a guard rail which carries a small table. The construction is of Swedish fir, rungs of Quebec birch, with locks of steel to fall under any of the rungs, and actuated by an iron rod. Pulleys are fixed over which a rope runs in such a way that the upper section is raised or lowered with the greatest ease. Mr. Heathman, of 2 and 37, Endell-street, London, who supplied this telescopic ladder tower, is always busy designing new arrangements to suit the requirements of electrical engineers.

ELECTRICITY AND SOME OF ITS USES.*

BY SIR FREDERICK BRAMWELL, F.R.S., M.I.C.E.

I am honoured by the permission to deliver a lecture on the above subject before you this evening. At the outset I desire to make an apology (which I have no doubt I shall be tempted to reiterate during the course of my address)—namely, that I think it is all but a piece of impertinence to endeavour to compress any useful account of electric science as a whole, or to make any attempt to describe a tithe of the multifarious uses to which electricity is now applied within the short space of time that can be allotted to a single lecture. I purport to be about to lecture to you on electricity, and the very first statement that I have to make is a damaging one. I do not know what "electricity" is. But, on the other hand, I do not know what "heat" is. In a celebrated work "heat" is called "a mode of motion." I think I must be equally safe as regards "electricity," and say it is "a form of energy."

Although I do not know what electricity is, I know many ways of producing it, I know many ways of using it, and also know that it is a thing that can be bought and sold—a circumstance which, I trust, will be of growing interest to the inhabitants of Derby and to its Corporation. The following are some of the "many ways of producing it": I rub a stick of sealing-wax with a piece of dry fur. To show you it is electrified, I bring it near to this pith ball, with the result that the ball is moved. Similarly, I rub a rod of glass with a piece of dry silk, and I present that to the ball, and the ball moves. I have here another instrument which moves when affected by a current of electricity. I dip a plate of two dissimilar metals—zinc and copper—into some weak acid, and you will see the instrument indicates the presence of an electric current. I have here a series of plates of two dissimilar metals united at one end, and I heat these metals at their junction, and again you see the indication. In Canada, in the winter time, when the air is dry, it is a common thing for a man to rub his feet on the hearthrug, and thus to be enabled to light the gas with an electric spark from his knuckles. When I had more hair on my head than I have now, and the wind was north-east, the atmosphere being correspondingly dry, I have heard the crackling produced by combing my hair, and on turning out the light I have seen most unmistakable lambent flame as a result of the combing. I am sorry I cannot show you the hydro-electric machine constructed by Lord Armstrong many years ago, but I have put a drawing on the wall, Diagram 1. I need hardly say I do not put forward these diagrams I show to-night as works suited for your Art Gallery. You will see this apparatus of Lord Armstrong's consists of a steam-boiler carried on supports insulated from the earth. The steam escapes by the pipe, "A," and the friction produces powerful electrical effect. I have here a little implement, no doubt well known to you, which, on being operated, generates electricity adequate to light a gas jet.

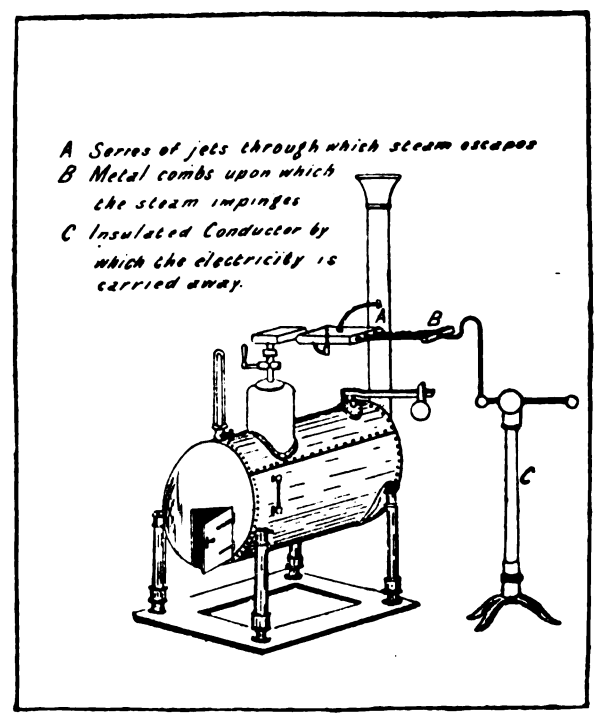

A Series of jets through which steam escapes
B Metal combs upon which the steam impinges
C Insulated Conductor by which the electricity is carried away.
A
B
C

DIAGRAM 1.

I will now come to the much more important way of producing electricity in practice by the dynamo. The elements of action of a dynamo are—relative motion between convolutions of copper wire (or their equivalents) and a magnetic field. With respect to the magnetic field. I have here a permanent magnet, and, you will see, in the usual way these iron filings arrange themselves when spread on a piece of paper, that there is, as it were, "a virtue"—as it would have been called in olden times—or "a field," as we now call it, prevailing about the pole of the magnet. If I move backwards and forwards within this field some convolutions of copper wire, you will see that electricity is being produced.

I think I have now sufficiently justified my statement that this unknown thing, electricity, can be produced in many ways. With regard to its "uses in many ways." The first one with which I will deal is, for practical purposes, of the very highest importance—namely, its ability to produce magnetism. I have here an electro-magnet made of soft iron wound round about with insulated coils of copper wire, through which, at the present moment no current is circulating, and, as you will see, when I offer to it a handful of nails, there is no trace of magnetic action. But on passing an electric current through the coils, the nails are greedily seized and held by the soft iron, which has now become a magnet. I showed you that a permanent magnet, when a coil of wire was moved about within its influence, generated electricity. A very obvious mode of moving such a coil or coils is to place them upon an axle and to turn the axle. This principle of construction is carried out in the small dynamo, which I now show you, and, on the coil being set into rotation within the field of the permanent magnet electricity will be developed, as you will see by the fact of its lighting up this small incandescent lamp. Thus muscular energy has been turned into electrical energy, and has produced heat and light.

* Lecture delivered at the Guildhall, Derby, on May 16, 1894.

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Now, that which is true of the effect of moving coils in the field of a permanent magnet is equally true, it need hardly be said, of moving them within the field of an electromagnet; and as such magnets can be made of any power required, the modern dynamo is, for industrial purposes, I may say always, constructed with electromagnets. It is an interesting fact in the history of electric lighting that the "Holmes" dynamo, having permanent magnets, which was tried at Blackwall in 1857 and then exhibited in the Exhibition of 1862, was, when I last visited the South Foreland Lighthouse—some three or four years ago—still at work, generating electricity for that light. You will have seen that to have an electromagnet we must first of all have a current of electricity, and the enquiry therefore is a pertinent one—Whence comes, in the first instance, the current to make the electromagnet? One of the early modes adopted for obtaining this was to use a permanent magnet in connection with a small dynamo, and to employ the electricity generated thereby in exciting the electromagnets of a larger machine. But after a time (and not a very long one either) it was found that the electricity produced by any continuous-current dynamo might be caused in whole or in part to traverse the coils of its own electromagnet, and thereby to establish its own magnetic field. But you may again say, "How do you get the first start?"

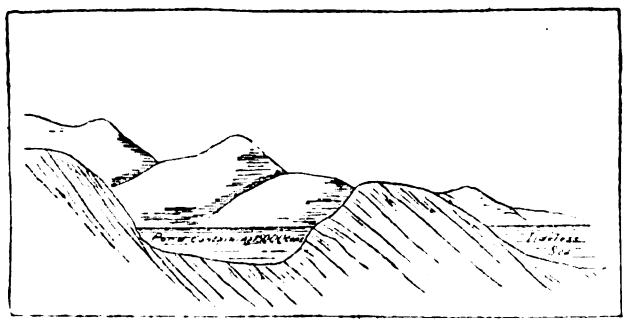

DIAGRAM 2.

In the very outset, by the effect, feeble though it be, of the magnetism of the earth. Afterwards, by the same source and by the residual magnetism—*i.e.*, the magnetism remaining in the metal of which the magnets are composed. I have shown you that when a convolution of wire is moved within a magnetic field the character of the electricity varies according as the movement is towards, or away from, the pole of the magnet, and also varies with the nature of the pole, whether a north or a south. You will say, therefore, at once that any dynamo constructed as I have suggested must produce a current which alternates—that is to say, is alternately in opposite directions. This is so, and the whole incandescent lighting done by the Corporation of Derby is—as I shall explain to you hereafter—done by means of an alternating current, and the magnets of the dynamos for producing this current are excited by electricity produced by small continuous-current dynamos. Your arc lighting, however, is done by continuous-current dynamos, and these, as I have already suggested to you, excite their magnets by the electricity they themselves have produced. I ought, perhaps, to tell you that a continuous current is obtained by "sorting," as it were, the alternating effects of the primary movement of a dynamo, so that all the impulses are directed one way.

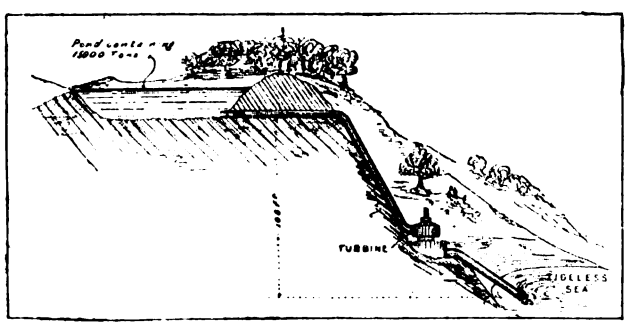

DIAGRAM 3.

We have now, very hastily and very imperfectly, reached the stage of my lecture where I trust I have shown to you how electricity can be produced sufficient for industrial purposes, and I must ask your indulgence for a little while I direct your attention to certain matters which must not be forgotten when considering the production and use of electricity. I find many persons, in common with myself, confess to more easily comprehend certain electrical facts by an analogy from behaviour of water, and I therefore propose to employ this to illustrate many points. Imagine a pond in a marsh, at the level of a tideless sea, say, a pond containing 15,000 tons of water as illustrated on Diagram 2. You will see that there can be no possibility of this water doing any work, in the way of driving a waterwheel. Suppose one were to cut a channel between the pond and the sea and to put a wheel in it. The pond and the sea being of one level, no flow of water would result, and the wheel would not turn. But look at the Diagram 3, where we have assumed the pond to be on the summit of a cliff 100ft. above the sea. If the water, under these circumstances, had an outlet from the pond, say, by a pipe sufficiently large to allow of 15 of tons water per minute flowing through it, and we were to put a turbine in that pipe, power would be obtained. In fact, the wheel would deliver, if there were no losses, that which is known as 100 h.p., and for nearly 1,000 minutes, or till the pond was empty. You will see I have contrasted the state of things where there is a body or weight of water having no fall, with a similar body or weight of water where there is a fall of 100ft. Let us make another contrast—10,000ft. fall or more, if you like, but with only an ounce weight of water to fall down. Obviously, this would be useless for power purposes. That which is really needed for purposes of obtaining power is quantity or weight of water multiplied by height for it to fall through. These facts, as regards water, are equally true as regards electricity, but we measure this, not in tons, nor in gallons of 10lb. each, but in "amperes." This is not a mere question of difference of name, as for practical purposes we cannot put electricity into a measure of capacity. You may, perhaps, have the notion, as you have heard of "storage batteries" (about which, if time admits, I hope to say a word or two), that electricity can be stored, as gas is stored in a gasholder. I wish it could be. It would be a delightful thing if one could have a small electric plant constantly working, and storing real, ready-made electricity to be used as we wanted it. You may ask me if an "ampere" is really a measurement. Although not a direct measure of quantity, it is an inferential measure of quantity, and again, to enable us to comprehend the difference the analogy of water comes to our aid. Take the case of an old-fashioned country millwright, who is asked as to whether a particular stream will drive a mill similar to one situated on another stream, the falls being equal. Such a man does not bother himself about gallons or cubic feet of water, but he takes a board to the existing mill, and puts it into the stream in the tail race from the mill, having previously cut a notch, say 4ft. long, in the board, and he sees how high the water working the mill is when passing the notch, taking care that all the water flowing down shall go through the notch. He takes the board back to the intended site, does the same there, and then finds that the water rises in the notch to the same, or to a greater height, and says at once there is the same, or may be more, water. But if it does not rise to the same height he may have, in fact, to reduce the notch

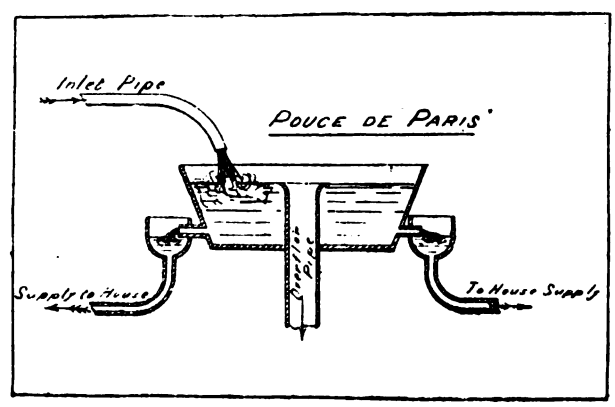

DIAGRAM 4.

from 4ft. long to 2ft. long, before the water will rise to the old height. Under these circumstances, he says at once, there is only half the water here that there is at the other place, and this, although he is ignorant of how much water there is in either stream. Water for domestic purposes has been sold in a somewhat similar way. Diagram 4 shows, very roughly, how this was done in Paris. The water was pumped into a cistern in a tower. By means of an overflow pipe that water was kept at constant level. Round about the edges of the cistern, at a uniform distance below the surface of the water, holes of 1in. diameter, or the diameter of the thumb, were made, and the customer, according to the size of his house, took as much water as flowed through one thumbhole, or two, three, or four holes, and he paid so much for the water supplied by each hole, "Pouce de Paris." It was obviously perfectly fair. If the total income needed were 1,000 livres per annum, and if there were 1,000 holes, and for each hole one livre was paid, then the man with the small house being satisfied with the produce of one hole paid one livre, and the man with the large house, needing the delivery from 10 holes, paid 10 times as much—that is to say, each paid in proportion to what he got. Neither knew how much it was in actual quantity, but they knew it by "rate of flow." An "ampere" is a "rate of flow" of electricity.

Next, with regard to pressure of electricity. This is measured not in "feet head" or "fall," as water is, but in "volts." Once more, reverting to water. In Diagram 5 I have shown two hydraulic lifts or rams. Assume one of these has an area of 10in., and that there is a head of water or pressure of 1,000lb. on the inch. Such a ram would support a load of 10 by 1,000 equal to 10,000lb., and for every foot it rose there would be 10,000 foot-pounds of energy. The other ram I have shown to have an area of 20in., but with a water pressure of only 500lb. per square inch, but 20 by 500 again gives the 10,000, and again for every foot this ram rose there would be 10,000 foot-pounds of energy. Similarly, in electricity. If I have 10 amperes of quantity by 1,000 "volts" pressure, I obtain 10,000 "volt-amperes," called "watts." Again, if I double the amperes, and use 20, but at only 500 volts or one-half the pressure, 20 by 500 equals the 10,000 volt-amperes, or "watts." That is to say, in these two cases the electric energies

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will be equal. Now, depending upon a number of details, into which time will not permit me to enter, a dynamo can be constructed and worked to produce electricity either at a high or at a low voltage. Assume two dynamos to absorb, say, each, the power of a 10 horse engine. They will turn out equal amounts of electrical energy, but they may do it, as I have suggested, either by a large output of amperes with a low voltage—such, for example, as is used in practice, in electric deposition, or in electric welding—or they may turn out a relatively small quantity of amperes, but at a proportionately high voltage, such as I will show you is useful in the arc lighting of your town.

As our time is limited, I think I had better at once proceed to talk about electric lighting in the two ways in which it is practically carried out—by incandescent lamps and by arc lamps With respect to incandescent lamps: I will begin with the very

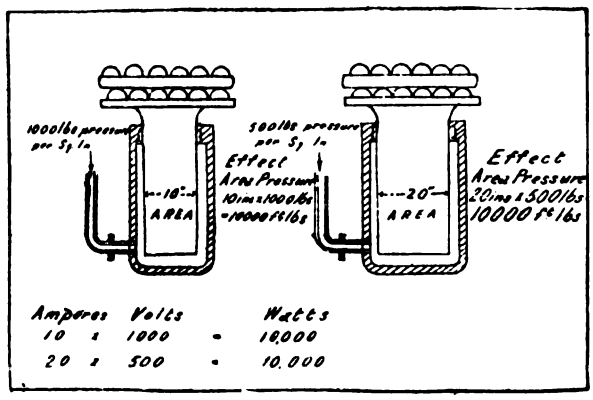
1000lbs pressure per Sq In
Effect Area Pressure 10 ins x 1000 lbs = 10000 ft lbs
10"
AREA
500 lbs pressure per Sq In
Effect Area Pressure 20 ins x 500 lbs = 10000 ft lbs
20"
AREA
Amperes Volts Watts
10 x 1000 = 10,000
20 x 500 = 10,000

DIAGRAM 5.

old experiment, showing the result of the passage of an electric current through a piece of iron wire, which I can gradually shorten. I will start by transmitting the current through the whole length of the wire You will not observe any glow, but you will see it is hot, for it lights a match. The heat is due to the dissipation of electrical energy, owing to the resistance of the wire to the passage of the current and the reconversion of that energy into heat. I will now cause the current to flow through only half the length of the wire, and you will find the wire will begin to glow. You may say, "Why is this, as you have got only half the resistance you had before?" The answer is, that the resistance being halved, double the number of amperes are now flowing through, and that the loss of energy is intensified per unit of length, for it is double what it was before, and it is exercised in half the length It is, therefore, four times as great. I will continue to shorten the length of wire through which the current passes, and you will see that the brilliancy increases and increases until the wire fuses and breaks. I have used, as I told you, a piece of iron wire. Had I used a piece of copper or silver wire of the same size I should not so readily have obtained similar results, because copper and silver are much better conductors of electricity than is iron. To show

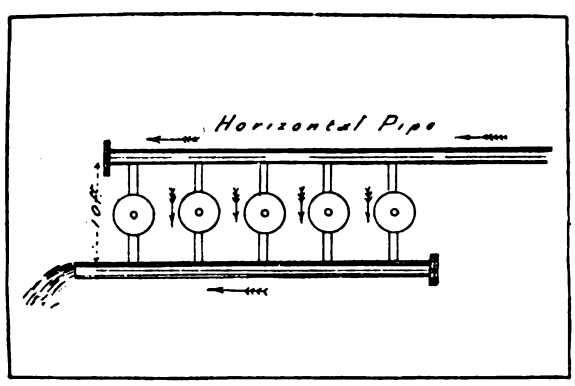

DIAGRAM 6.

the difference in the power of conduction of different metals, I have here a rough chain made of alternate links of silver wire and of platinum wire of equal diameters. I pass a current through this. You will see that every alternate link (the platinum) gives light, while every alternate link (the silver) remains dark, proving that the silver is the better conductor. You may be tempted to say, "Why this is the glow or incandescent lamp that is wanted. All that is necessary is to employ a fine platinum wire." Much time, and thought, and money were spent in this direction, but they were all wasted. When platinum is heated sufficiently to give a proper glow, it speedily perishes. It would occupy the whole evening to go through the mere history of incandescent lamps. We must leave it on one side, and I must content myself by saying briefly that, as you all know, incandescent lamps are made in these days by the employment of a charcoal—*i.e.*, carbon—filament. There is one unhappy difference between platinum and charcoal. The latter cannot be used in contact with the air, even for as long a time as the platinum. I have here a lamp to which I have admitted the air. I pass a current through the filament, and, as you see, it is destroyed almost immediately. But if this same filament be enclosed in a glass bulb from which all the air has been exhausted, the filament can only glow; it cannot burn to destruction, for there is not any air to support combustion, and the light is obtained. An incandescent lamp is so very familiar an object, and it appears so very simple now that we know all about it, that one is hardly disposed to accord to it the admiration it deserves, for it is the outcome of years of deep thought and hard work, and even now the processes employed in its manufacture are by no means simple. But although, speaking generally, it has ceased to interest us, to my mind it is a marvellous thing that a mere thread of charcoal, $\frac{1}{100}$in, in diameter, or less, should be brought to so hard a condition as to be as elastic as a steel spring, and that this slender thread should be heated to a point competent to give light in quantity sufficient to illuminate large rooms without being itself destroyed. This is all time will allow me to say about electric incandescent lamps.

I will now consider the modes adopted for distribution of electricity through a town to a number of houses, and the use of the electricity there, whether "in parallel" or "in series," and to make my meaning clear, I must use again a water illustration. In Diagram 6 I have drawn a horizontal pipe, conveying a large quantity of water, enough to work a certain number, say five mills, the pipe supplying to each of them 15 tons of water a minute.

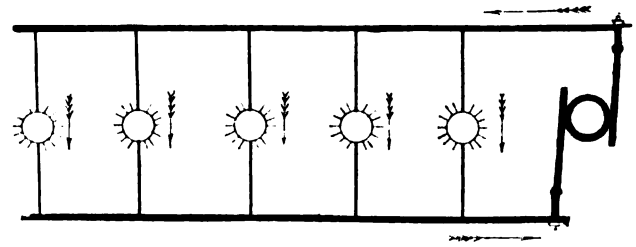

DIAGRAM 7.

Ten feet below the first pipe, and parallel with it, I have drawn a second pipe, and between these two I have placed the five mills, the only connection between the pipes being through the mills. If all the mills were stopped, the water would not flow from the one pipe to the other. If one mill were put to work it would take its 15 tons per minute; if all five were put to work, they would take their 75 tons per minute. This may be called the "parallel"

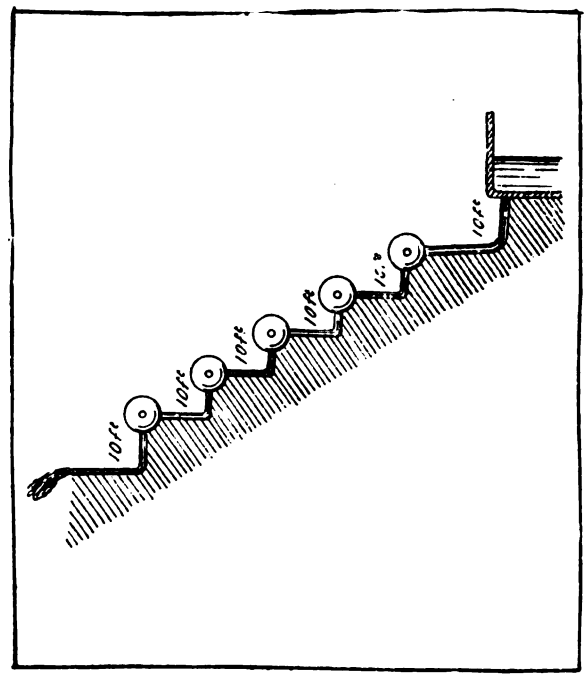

DIAGRAM 8.

system of water distribution. In Diagram 7 I have shown the electrical comparison—a dynamo, with a wire coming out from it. Parallel with that, another wire going back to the dynamo. The only connection between these two wires being through five incandescent lamps Suppose each lamp to take a third of an ampere. If one is at work, only one-third of an ampere is flowing from one wire to the other. If all five are at work, then one and two-thirds are flowing. I have given you these small numbers of lamps; but, of course, in practice they are multiplied by hundreds or thousands. If the difference in voltage between the two wires be, say, 100 volts, it is obvious that each lamp is using one-third ampere by 100 volts, and this is an arrangement very commonly employed.

I will now go to another system of distribution. Diagram 8 shows the water-pipe, no longer horizontal, but descending a steep hill-side. The pipe is much smaller, as although each of the five mills drawn requires the same power as any one of the five mills on the "parallel" system, only sufficient water need be brought to work the first mill, or one-fifth of the quantity in the former case. For, being on the steep hill-side, we can put the

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second mill 10ft. below the first, and the water which has worked the first mill will pass through the second and work it, and so on, to the fifth. But you will see that, although we have used only a fifth part of the water we did in the "parallel" system, that fifth part has fallen through, not the 10ft. fall of the "parallel" system, but a 50ft. fall, and therefore the water energy expended has been the same (as you will realise it must be), to do the same work. Similarly, in electric lighting, the lamps may be "in series," as shown on Diagram 9. I have before me a row of incandescent lamps which are "in series." The same quantity of electricity flows through all the lamps, but I am compelled to have four times the pressure or voltage for these lamps in series that is needed for each single lamp. I have hitherto dealt with incandescent lamps only, but you are well aware that there is another kind in your streets—the arc lamp. In the case of these lamps there is not any filament carrying

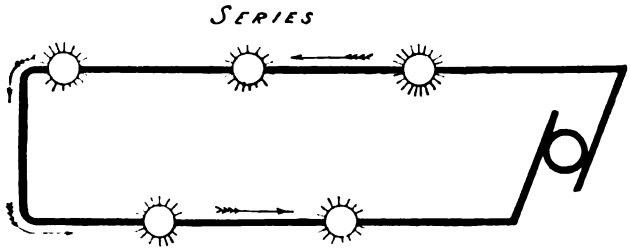

DIAGRAM 9.

a current through it; but there are two sticks of carbon, in holders, capable of moving towards one another, and these sticks are by most ingenious arrangements maintained with their ends at the proper distance apart, to cause the electricity to experience the requisite resistance in leaping across the space between the ends, thus making that which is called the "arc" from carbon to carbon. Each of these lamps requires about 10 amperes, and each lamp involves the lowering of the electrical pressure by about 45 volts. Now, as in the case of the "series" water mills, if I were to start with 10 amperes, at 45 volts it would light one arc lamp; but if I start with the 10 amperes, at 90 volts, then after the electricity has passed through the first lamp there would still be 45 volts left, which would be competent, therefore, to light a second lamp. But if I started at 450 volts I could similarly light 10 lamps; or, if I had 1,800 volts, I might light 40 "in series." The construction of these arc lamps is so extremely ingenious, having regard to the automatic arrangements by which the ends of the carbons are kept at the right distance apart, notwithstanding they are constantly burning away, and by which, if any failure occurs, so that a lamp ceases to burn, the electricity shall still go through the lamps before it and after it, and thus prevent the whole of the 40 lamps "in series" from being extinguished by reason of the failure of any one of them, that I very much regret time will not admit of my giving you some description of these most ingenious arrangements, but I show you here one of the lamps such as are employed in your street-lighting. By this time you are aware that the ratios of the quantity and of the pressure of electrical energy may be varied; and also that the size of the mains must depend upon the quantity of current they have to carry, and not upon the pressure at which that current is passing. It is desirable, therefore, to increase the pressure within reasonable limits in order to keep the mains small.

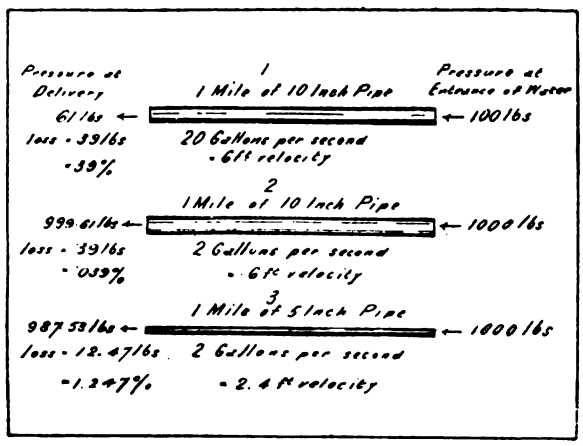

DIAGRAM 10.

I will once more revert to a water analogy. If I desire to convey power, hydraulically, by means of water having a pressure of 100lb. on the square inch where it enters the main, as shown in Diagram 10, and to convey it one mile, and that I have a 10in. pipe, and the quantity I need is 20 gallons a second, equal to 6ft. velocity; then, without troubling you with the calculation, you may take it from me that the loss of pressure due to the overcoming of the friction through the pipe will be 39lb. out of the 100lb. per square inch, leaving an effective pressure at the delivery end of the mile of pipe, therefore, of only 61lb., the loss being, as you will see, 39 per cent. But take the next case shown on the diagram, where the water pressure at the entering end of the pipe has been increased to 1,000lb., equal to 10 times as much pressure. I can, with such a pressure, perform the same work by a tenth part of the water, or only two gallons per second, equal to 6ft. velocity. The actual loss in pressure under these circumstances will only be 39 of a pound, so that you see the losses in pressure diminish as the square of the quantity, but the percentage loss differs in a much higher ratio—namely, inversely, as the cubes of the pressures, for it becomes reduced to 039, or about $\frac{1}{25}$th of 1 per cent. For practical purposes, however, one does not retain the same size of main, either for water or for electricity, when high pressures are used, but advantage is taken of the altered state of things to diminish the size of the mains. On the same diagram I have shown what would happen if a 5in. main were employed, instead of a 10in. main. The two gallons per second would now demand a velocity of 2·4ft., and the 1,000lb. pressure would be reduced to 987½, giving a loss of 12½lb. out of the 1,000lb., or 1·25 per cent. Similarly, with electricity. There is a loss in pressure by conveying it along the conductor, depending upon the quantity (amperes) put through. The actual loss of energy can be decreased by reducing the amperes and correspondingly increasing the voltage, and the percentage of loss, as in the case of water, will be still more decreased. Having regard to the frequent desirability of being able to place the generating station at some distance from the parts of a town where the electricity will most commonly be used, or it may be to the large area to be lit from one station, and to the great cost of the large mains needed to transmit sufficient energy at a low pressure, it is obviously advantageous to have means by which the pressure may be increased and the quantity passing be reduced while still delivering the same amount of electrical energy For purposes of "transport," if I may use the term, it may therefore be very desirable to have a pressure of, say, 2,000 or 3,000 volts at the generating station and in the mains or some of them; but one would hardly care to have that pressure in a dwelling-house, and, moreover, for the purposes of incandescent lighting, one could not, in the present state of the art, employ such a pressure satisfactorily in a lamp.

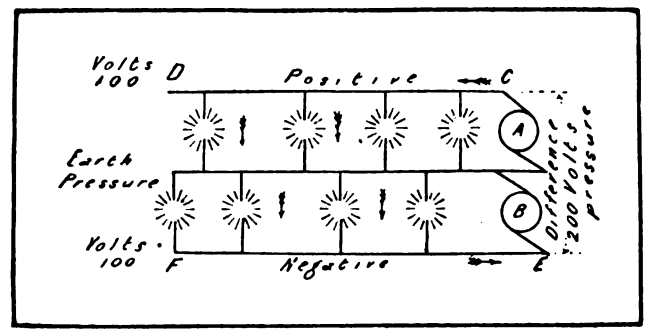

DIAGRAM 11.

Up to the present time the pressure which is commonly employed in an incandescent lamp is 100 volts, but lamps of 200 volts are in use, and I think it not at all improbable that before long incandescent lamps of 200 volts, or of even higher pressures, may come into very general regular use. But for the purpose of illustrating one mode by which the pressure of transmission may be reduced to the pressure employed in the lamp, I will ask you to look at Diagram 11, illustrative of the "three-wire system." I think I cannot do better in describing this arrangement than use the very words of Dr. John Hopkinson, the inventor of this system, as given in his patent specification, where he says: In order to combine the advantages of comparatively high potential in the feeding conductors with lower potential in the houses in which the electricity is used, I make use of a system of three conductors in combination with two dynamo machines coupled in series . . . "A" "B" represent the two dynamos, "C-D" and "E-F" represent the extreme conductors, which I call the positive and negative conductors, and "G-H" represents the intermediate conductor. The positive pole of the dynamo machine, "A," is connected to the conductor "C-D," and its negative pole to the conductor "G-H." On the other hand, the positive pole of the dynamo machine, "B," is connected to the conductor, "G-H," and its negative pole to the conductor, "E-F." The houses to be supplied are divided into two approximately equal parts, preferably the houses being taken alternately. The houses of one part are supplied between the conductor, "C-D," and the conductor, "G-H"; and those of the other part between the conductor, "G-H," and the conductor, "E-F." The intermediate conductor, "G-H," may be of much smaller dimensions than either of the other two, as it has only to carry the difference of current consumed by the two divisions of consumers—that is, those connected with the conductor "C-D," and those connected with the conductor "E-F." It need not be insulated, and, indeed, it may be replaced by the iron, or other metallic covering, often used to protect the copper conductors. In cases where the two divisions of consumers may be safely assumed to have a very approximately equal consumption at all times, the intermediate conductor, "G-H," may be replaced in part by the earth, and the negative pole of the dynamo machine, "A," and the positive pole of the dynamo machine, "B," be connected together and to the earth. You will realise that it is obvious this principle may be carried to more than three wires, and on this point Dr. Hopkinson says: "This system may be extended by using more than two dynamos in series, and

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dividing the consumers into as many groups, there will then be two large conductors connected to the extreme poles of the dynamos and a number of smaller intermediate conductors, one less than the number of machines, each connected to the junction of two machines of the series."

I think you will agree with me that the three-wire system is a very ingenious method of enabling the mains to be reduced in size when the current has to be delivered to consumers spread over a large area; but there is another mode—namely, that of the use of induction coils, now called transformers, by means of which much larger changes in voltage, between that of generation and that of distribution, can readily be made. I will ask you to look at Diagram 12. You will see there a comparatively fine wire, making 20 turns round about a bar, on which there is also a single turn of a comparatively coarse wire. The fine wire has delivered to it a comparatively small quantity of electricity, but at a high voltage—say, 2,000—the result of the arrangement being that, although there is no connection between these two wires, but mere contiguity, the single coil of wire will have generated in it electricity, with the pressure reduced to one-twentieth part, or down to 100 volts, while the quantity will be increased 20 times. These are the ratios in use in the transformers in this town. That is to say, the current at the station is generated at a pressure of 2,000 volts, or even higher, and is reduced by transformers in the street boxes to the safe pressure of 100 volts, at which it is distributed, and enters the houses of consumers. I should have said that this action only takes place with such an implement as this when there is a change in the condition of the electricity passing through the fine wire, such as very rapid intermissions in a current all in one direction, or such as—and this is commonly the practice for commercial purposes—the changes attending the employment of an alternating current.

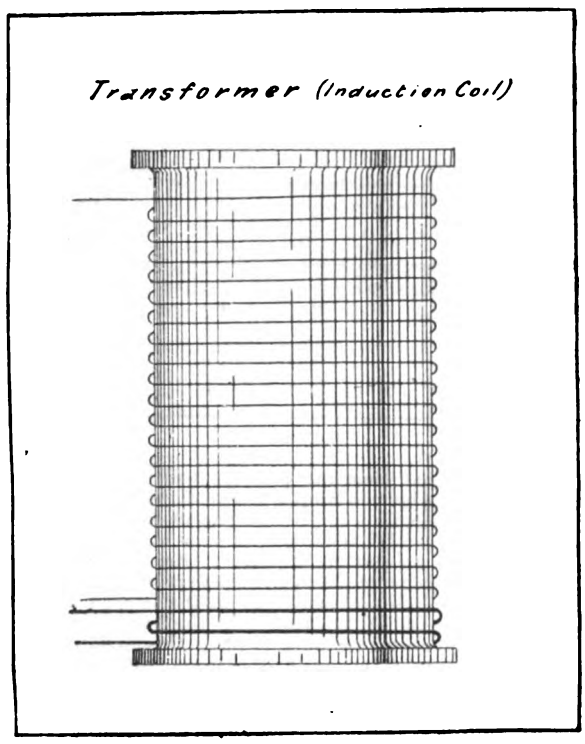

DIAGRAM 12.

Continuous current of high voltage can be reduced to continuous current of low voltage by causing the current of high voltage to drive a motor which drives a dynamo so wound or arranged as to produce low-voltage electricity. If you will remember, in the very early part of the evening, I pointed out that the currents produced by the dynamo were alternating, and that they were made continuous by a "sorting" arrangement. If this "sorting" be not done, then an alternating current is obtained, and it is, as I have said, that such a current is sent through your streets, and is made use of in the transformer. I have here before me two implements that have been in use for very many years under the title of Ruhmkorff coils, but which are really transformers. The one on the right hand is receiving a rapidly interrupted current from a primary battery having a low voltage. It is increasing this voltage enormously and is correspondingly diminishing the quantity, so that I am enabled to transmit the electricity by the extremely fine wire which you can hardly see, that extends from one of these coils to the other. On applying this current to an electric lamp, you will see that no glow is produced. But the second transformer is being worked in the reverse way to the first—that is, the electricity is being changed back again into low voltage and considerable quantity, and a lamp put into the circuit at this part will light up efficiently.

I promised that if time admitted I would say a few words about storage batteries or accumulators, as they are generally, though erroneously, called. The pair of plates of dissimilar metals immersed in a suitable liquid, such as I used early in the evening, and the battery I have just employed with the Ruhmkorff coils, are called primary batteries, and they will continue to work for a certain time until the active element becomes exhausted, when this element must be renewed before more electricity will be produced by them. The so-called storage battery, when in use, consists in the employment, as in the primary battery, of practically two metals, but actually of only one metal—lead—but in two different states or conditions; this is immersed in an appropriate liquid. It differs from a primary battery, however, in that when it is becoming exhausted, by reason of the plates of metal tending to come into similar conditions, instead of remaining in dissimilar conditions, the sending of a current of electricity the reverse way through the battery will restore the plates to their dissimilar condition, and thus render the battery once more capable of going to work and producing electricity. You may have noticed I used the term "so-called storage batteries," and I have done so because they do not "store" electricity, but they have within them the potentiality of going to work and of producing electricity. If anyone were to send you 9,000lb. of water heated up to the boiling point, you might properly say that he had given you a "storage of heat," as much as would require, say, 100lb. of coal to raise it from the temperature of the air to the boiling-point in an ordinary boiler. But if instead of the 9,000lb. of hot water he had sent you 100lb. of coal, it would hardly be correct to say that he had sent you so much heat. It would be true that he had sent you "the means" of producing so much heat—the "potentiality." So, therefore, a so-called storage battery has within it not the electricity, but the potentiality of producing it.

I am afraid I must ask you to be content with this most imperfect sketch of electricity generally, and of its application to lighting purposes. Time will not permit of my giving you more detail. I told you that I do not know what electricity is, but that I did know many ways of producing it, and also many ways of using it. At present, I have only dealt with one of those ways—namely, lighting. But the other ways are numerous now, and no doubt will be much more numerous a few years hence. A very early employment of electricity, as you all know, was in electro-plating—that is, the deposition of a metal out of its solution. Nowadays this process is carried to such an extent as to be used not only for mere plating, but for forming the whole substance of an article. Copper tubes, for instance, are made entirely by the deposition, electrically, of copper from its solution. The old use, telegraphy, I need not more than mention. The more modern use, telephony, at this time excites no attention whatever, although if 20 years ago it had been asserted that speech uttered in London could by the aid of electricity be not conveyed, but reproduced in Paris, or, as it is daily, in Derby, it would have been looked upon as an absolutely idle, or may be false, suggestion. Welding is a use of electricity. By the aid of appropriate machinery to give pressure, pieces of metal heated by the passage through their extremities of an electric current can be welded with absolute cleanliness and certainty. And many metals of which the welding point is so near to that of absolute fusion that they cannot be welded by ordinary means, can, by the aid of electricity, be thus united. Aluminium is a striking example of such a metal.

With regard to transmission of power, you are all aware that you can construct an implement, exactly like a steam-engine, with its cylinder, and piston, and slide valves, which, if you turn it round by some power, will pump water, and that this very same machine, if supplied with water under pressure, becomes an hydraulic motor—implements such as these being largely used for working capstans on the quays and docks, and in railway goods yards. Similarly, if you turn a dynamo round by power, it will produce electricity; but if you supply it with electricity, it will act as a motor. I have such an implement here, and you will see it go to work, driving a blowing fan. By means of such motors, tramcars and the City and South London Railway and the overhead railway at Liverpool, are being worked. You have, within the last few days, opened here in Derby an exhibition, where may be seen specimens of electromotors, of the machinery, plant, and implements used in electric lighting for domestic and public purposes, ornamental internal fittings and lamps, and apparatus employed in the useful and comforting operations of heating and cooking, of kettle-boiling, of heating electric irons for laundries, and it would not surprise me to hear of electric curling irons for ladies' hair. At you all doubtless know, electricity is also used in many industrial undertakings—in bleaching, for the treatment of sewage, and for innumerable other purposes.

Such are the uses of to-day. It is impossible to say how far these may be extended, even in the course of the next 10 years, but that such extension will come is absolutely certain. I must now bring this lecture to a conclusion, begging of you to remember that nothing but the barest outline sketch can be given of so vast a subject in a single lecture.

THE PACIFIC CABLE QUESTION.

Sir Charles Tupper has sent the following reply to Sir John Pender in reference to the letter printed in our last issue:

Victoria-chambers, 17, Victoria-street, London, S.W.,
May 17, 1894.

Dear Sir John Pender,—In reply to your letter of the 15th inst., received yesterday, after I had read it in the *Times*, I must first express my regret that you were prevented by indisposition from being present when my paper (of which I had sent you a copy)

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was read at a meeting of the Royal Colonial Institute on the 8th of May.

You say: "I cannot allow your statement to pass unchallenged that 'the protest against the proposed cable is largely based upon fallacies.'"

Those who read that protest will find that it is largely based upon two statements, which I regard as fallacious. First, that "the existing service was established solely by private enterprise—no Government subsidy, guarantee, or exclusive landing rights having been granted to the company."

I do not think any person reading that statement would suppose that the "existing" companies with which the proposed Pacific cable will compete are now, and for many years past have been, assisted by Government subsidies and guarantees, amounting to the present time to £2,100,000. The Eastern Extension Company alone have received of that amount about £643,000, and the African lines, described by you as an alternative route to Australia, £1,337,000.

Second, that the calculations made in the protest to show the unprofitable character of the undertaking assumed that the life of the cable would be only 14 years.

You say: "You are entirely mistaken in stating that some 5,350 miles (or about 30 per cent.) of the 18,000 of cable now forming the system of the Eastern Extension Telegraph Company is more than 20 years old and is still in working condition."

My authority for that statement was the Berne list, published in 1892, as furnished by the Eastern Extension Telegraph Company to the International Telegraph Bureau, and which I accepted as reliable. The following are the figures:

	Date of laying.	Length of cables in nautical miles.
From Madras to Penang	1870	1,455
From Penang to Singapore	1870	415
From Singapore to Saigon (Cochin China)	1871	637
From Saigon to Hong-Kong	1871	983
From Singapore to Batavia (Java)	1870	539
From Banjowangie to Port Darwin	1871	1,137
From Flinders, near Melbourne, to Low Head (Tasmania)	1869	180
Total		5,346

I will now add the highest existing authority on that question. Sir John Pender, at the meeting of the Brazilian Telegraph Company on the second of this month, said: "As you are aware, one of these cables is 20 years old, and therefore it is at all events approaching a period of age which causes us to be careful in providing for its renewal."

You say: "Then again your description of the existing system as a 'monopoly' cannot be justified."

I do not know what you call a monopoly, but I have under my hand the report made to the Government of Canada by Mr. Sandford Fleming (who was one of the Canadian delegates to the Colonial Conference, held in London in 1887). In that report, speaking of the discussion upon this cable question, he says:

"The Postmaster General (Mr. Raikes) stated very forcibly that it would be absolutely impossible for the English people or for her Majesty's Government to recognise the monopoly which the company seemed to claim."

With the evidence before me that the active efforts are now in operation to promote the construction of a Pacific cable under the control of a foreign Government, I cannot share your doubt as to its probability, nor can I agree with you as to the strategic value of a British Pacific cable, concurring as I do with the opinion expressed by the *Globe* of the 19th ult., which, in an article very friendly to the existing lines, says:

"In the first place, there can be no question at all that a cable across the Pacific would be of the very highest strategical importance to us. Not only would it furnish us with a duplicate medium of communication with our furthest colonial possessions, but it would also have the advantage of standing less chance of being cut by our enemy in time of war. The eastward bound cables, by means of which we communicate with Australia at present, touch far too many places *en route* to be strategically safe. Moreover, if an enemy should succeed in cutting the cable, it would probably be somewhere between Aden and England, in which case India would be completely cut off from telegraphic communication. The proposed Pacific cable, however, would then enable us to transmit our messages by an alternative western route."

I do not propose to discuss the question of traffic or the normal increase that may reasonably be expected further than to say that I have reason to believe that no difficulty will be experienced in securing the construction and operation of the cable upon the lines suggested by the Wellington conference, or such a modification as may be adopted by the conference shortly to be held at Ottawa.

Having confined my remarks to the principal points raised in your letter, I remain yours faithfully,

CHARLES TUPPER.

P.S.—I have sent a copy of this letter to the *Times*.
Sir John Pender, M.P.

Portsmouth.—It is reported that an armature was burnt out last week at the central station. Preparations for the starting of the installation are being actively continued, and 68 of the arc lamps were lit a few days ago. The Electric Lighting Committee have fixed June 6 as the date of installation.

REPORT OF THE ROYAL COMMISSION FOR THE CHICAGO EXHIBITION.

We give the following extracts from the report issued a few days ago by the Royal Commission for the Chicago Exhibition:

"The size of the Machinery Hall, including the annexe, was 1,396ft. long by 422ft. broad. In this building 33,000 square feet were allotted to Great Britain. This space was fully taken up in London by 60 exhibitors; 20 of these, however, failed to exhibit, and a space of nearly 6,000 square feet was left vacant. Some of this space was reallotted to exhibitors who came in at a later date, and, as far as possible, a readjustment was made of the previous allotments. Many exhibitors, however, had completed their stands, or had put down foundations, and were not able to shift their position even when a more advantageous space was offered to them. Eventually, vacant spaces, amounting in the aggregate to 2,000 square feet were left. The British section in this department was placed under the charge of Mr. H. D. Wilkinson, who was also responsible for the mining and electricity departments. The Chicago executive undertook to supply power for driving machinery in motion, but the chief of the department, Mr. L. W. Robinson, expressed a strong desire that power for driving the machinery in the British section should be supplied by British engines, and he undertook that, if the engines were lent and their freight paid to Chicago, all the expenses connected with their installation and working would be defrayed by the administration. The Commission were fortunate in obtaining engines under these conditions from Messrs. Galloways and Messrs. Willans and Robinson. Messrs. Galloways lent a horizontal compound engine, indicating 350 h.p. Messrs. Willans and Robinson provided two of their patent central-valve engines of 360 i.h.p. and 165 i.h.p. The details of the performances of these engines are given in a report by Mr. H. D. Wilkinson, which forms an appendix. Messrs. Willans and Robinson also showed one of their 300-h.p. engines coupled to a Siemens Bros. dynamo. This plant was placed at the disposal of the electrical department, and supplied current for four large Schuckert search-lights, which were shown every night on the Manufactures Building, and for other purposes. The performance of the engines supplied by Messrs. Galloways and Messrs. Willans and Robinson left nothing to be desired, and as each engine was of a distinctive and novel type in America, they both attracted considerable attention.

"In the Electricity Department, the building for which was 690ft. by 345ft., Great Britain was very poorly represented. Special efforts were made by the Electrical Committee, who were anxious to show at Chicago a typical English lighting station, and they also endeavoured to illustrate domestic electric lighting by showing a number of fitted rooms, as has been done in some exhibitions in this country. They, however, were not successful in either attempt. It had also been hoped that a share in the electric lighting of the exhibition might be allotted to some British firm, but the negotiations under this head came to nothing. It was by the division of the whole lighting scheme into sections, for which contracts were entered into with different nationalities, that the lighting at Paris was such a representative display. With one or two exceptions, notably in the case of Messrs. Siemens and Halske, who had the contract for lighting the terminal station, the whole of the electrical plant was American. In the Electrical Building no steam was furnished or allowed, the idea being that electrical power alone was most appropriate. This secured a grand display for the electrical transmission of power, but was fatal to a large class of exhibits of great importance. Practice in both lighting and power is now almost entirely in direct-coupled engines and dynamos, and such plant of this character as was exhibited could either not be run at all, or had to be run by making the dynamo a motor to turn the engine. This affected three exhibits. The reluctance of English electrical firms to exhibit at Chicago was no doubt due, at all events in part, to the fact that most of them had taken part in the special electrical exhibitions which have recently been held at Frankfort and at the Crystal Palace. The most important contribution in this department was the collection of historical telegraphic apparatus, lent by her Majesty's Postal Telegraph Department, and exhibited at the expense of the Commission. The collection included apparatus dating from 1837, and also modern telegraph apparatus, as used at the present day in our telegraph department."

Mr. H. D. Wilkinson, engineer to the British section, reports as follows in the appendix referred to:

"For operating the various machinery in the British section, power was supplied by the shafting, by steam, by electric motors, and by compressed air. Three exhibitors of looms ran their machinery by electric motor, because by that means they could operate for as many hours as they wished daily, whereas the line shaft was only run from 8 a.m. to 5 p.m. Except in the case of electric motors, no charge was made for the supply of power when the machines using the same were not performing any work, but where anything was being driven by engines or manufactured by machines, a charge was made for the power estimated to be in use. It was impossible to measure the power absorbed by the various classes of machinery operated, but in every case I was able to negotiate a satisfactory understanding between the exhibitors and the chief of the building as to the amount of power actually used, and upon this the exhibitors agreed to pay. Steam was charged at the rate of 40dol. for six months' supply per horse-power, or at four cents per horse-power hour. Compressed air was supplied at 60dol. per horse-power for six months, or at five cents per horse-power hour, and power from shafting was charged at the rate of 50dol. per

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horse-power for six months. Exhibitors who chose to drive by electric motors had to purchase their motors from the manufacturing companies, as they could not be obtained on hire. The company having fixed a motor, there was then the cost of connecting it to the mains, for which the exposition had a scale of charges ranging from 20dol. per horse-power for a motor of ½ h.p. or under. to 10dol. per horse-power for over 10 h.p. The current supplied was direct at 500 volts, and the scale of charges for the six months ranged from 80dol per horse-power for ¼ h.p. and less, to 60dol. per horse-power for over 2 h.p. Gas was also used for operating gas-engines and other exhibits, and was supplied from the works of the Hyde Park Gas Company, situated outside the exposition. The charge was made 1dol. 50 cents per 1,000 cubic feet, with a discount of 30 per cent. if paid within six days from date of bill; no charge was made for meters, but a deposit was required. A charge of 3dol. was made for a permit to open ground and make connection to main, besides which there was the cost of laying branch pipe to exhibitor's space, and the connections from branch pipe to exhibitor's machinery. In our section I arranged for one pipe to be laid, sufficient to meet all demands, and divided the cost of the same between the exhibitors requiring gas supply. Water was supplied from the exposition pumping station, and was charged for at the rate of 10 cents per 1,000 gallons. The water-meters put in by the department were charged to the exhibitors. The cost of fitting was as follows: permit for connecting to main, 3dol.; permit for connecting to waste, 3dol.; cost of meter, 15dol. to 25dol.; cost of branch pipe to exhibitor's space, and cost of plumbers' work to exhibitor's apparatus."

Another appendix deals with the engines in the British section. It is as follows: "The horizontal compound engine lent by Messrs. Galloways (Knott Mill Ironworks, Manchester) was suitable for indicating 350 h.p. at 70 revolutions per minute, with 100lb. boiler pressure. It had low-pressure cylinder, 30in. bore, placed over the high-pressure cylinder, 17in. bore, both having a stroke of 3ft. 9in. The piston-rods of these two cylinders drove on to one crank-pin by means of connecting-rods, the slide block for the low-pressure cylinder working on slide recessed in the bed-plate, and that for the high-pressure cylinder on steel slide bar forming a stay between the cylinder and the framing. The engine was fitted with Galloway's latest gear, the distribution of steam being effected by short slide valves. The high-pressure cylinder was provided with multi-ported or gridiron expansion valve working on the back of the main slide. The main slide was operated by eccentric from the crankshaft, and the expansion valve by curved slotted link, with an improved motion patented in 1890, allowing the admission of steam at full pressure, without the intervention of a throttle-valve, and giving a quick cut-off from any point from 0 to 66 per cent. of the stroke of the piston. The governor was driven by gearing, and was of the improved parabolic type, giving great sensibility and steadiness of turning; it was connected directly to the rod of the expansion slide-valve, which it controls, giving admission of steam according to the load upon the engine. The crank necks are 12in. in diameter, and the shaft carried a flywheel 23ft. in diameter, grooved for 12 1¼in. ropes. The condenser was placed in rear of the engine, the air-pump being horizontal, worked direct by continuation of the low-pressure piston-rod. The engines lent by Messrs. Willans and Robinson, Thames Ditton, Surrey, were Willans patent central-valve engines, of 360 i.h.p. and 165 i.h.p. respectively. They were single acting, all the brasses being kept constantly in compression, or 'in constant thrust' (instead of being alternately pulled and pushed, as in ordinary engines), with the object of enabling them to run with smoothness and silence at extremely high speeds; the normal speeds of the two engines shown being, for instance, 350 and 380 revolutions per minute respectively. To scientific engineers the engine is well known from the two series of trials carried out by its inventor, the late P. W. Willans, described in papers read by him before the Institute of Civil Engineers in London, in the discussion of which various American engineers took part. The economy figures given by those trials are still 'record figures,' the consumption falling as low as about 18½lb. per indicated horse-power per hour non-condensing, and to 12·6lb. and 12·8lb. condensing. The engines were in both cases triple-expansion, with high steam pressure (170lb.), but they were very small, indicating less than 40 h.p., and running at 400 revolutions per minute. The larger engine shown had three cranks, and of the standard 'III' pattern; the smaller one, with two cranks, was of 'HH' size. The single-acting 'constant thrust' engine is distinctively an English exhibit, as, although known in America, it was extensively used in England (in the form of an earlier type of the Willans engine) for several years before it was taken up there. English experience of it, in fact, extends over nearly 20 years. The one simple engine for combined dynamo and belt driving was of 60 i.h.p., at 470 revolutions per minute. Another engine, of 300 i.h.p., was also shown, coupled direct to a Siemens Bros. (English made) two-pole dynamo, capable of giving 180 kilowatts, or 200 if required. The machine was armed to give 1,000 amperes and about 112 volts, at 350 revolutions per minute. The combined efficiency of engine and dynamo was about 85 to 86 per cent.—that is to say, that for each 100 i.h.p., 85 e.h.p. or 86 e.h.p. is obtained at the terminals of the dynamo, and electrical losses in the latter amounting to 14 or 15 per cent. In plant such as that shown, with compound engines, the consumption of steam per electrical horse-power per hour is about 24lb. non-condensing, with triple-expansion condensing engines of the same pattern it falls to barely 15lb. Though exhibited by Messrs. Willans and Robinson, Limited, the makers of the engines, this plant was lent by Messrs. Siemens Bros., Limited, of Woolwich, England, to whom it belongs."

An appendix is also given by Mr. Wilkinson concerning the supply of electricity. He says: "It was by the division of the whole lighting scheme into sections, for which contracts were entered into with different nationalities, that the lighting at Paris in 1889 was such a representative display. With one or two exceptions, notably in the case of Messrs. Siemens and Halske, who had the contract for lighting the terminal station, the whole of the electrical power plant was American. Secondly, in the Electrical Building, no steam was furnished or allowed, the idea being that electrical power alone was appropriate to use. This secured a grand display for the electrical transmission of power, but was fatal to a large class of exhibits of great importance. Practice in both lighting and power is now almost entirely in direct-coupled engines and dynamos, and such coupled plant here exhibited could either not be run at all, or had to be run by making the dynamo a motor to turn the engine. This affected our section in three exhibits. The general lighting of the various buildings was by arc lamps run in series on direct-current circuits, but for all incandescent lamps and arc lamps required by exhibitors the supply was by high-tension alternating current with transformers. The high-tension wires at 2,500 volts were carried through subways to the principal points in the grounds, and from transformer pits located at points along the route current at 100 volts was taken into the various buildings. The contract for the supply of this current was in the hands of the Westinghouse Electric Company. The charge made by the Exposition Company for the use of lamps for six months was as follows: per incandescent lamp of 16 c.p., 8dol.; arc lamp of 2,000 c.p., 60dol. To obtain this service the exhibitor had to pay the above in advance, together with the cost of making connection, wiring, and fixing lamps—viz., per incandescent lamp, 3·50dol.; per arc lamp, 3·50dol. The New York Insulated Wire Company had the exclusive right of putting in all wiring for exhibitors, and instances occurred in our own foreign section in which exhibitors had put in their own wiring, but could not obtain current for their lamps until they had paid the above wiring charges to the exposition. There was great delay in the fixing of exhibitors' lamps, as the first attention had to be given by the electrical department to the general lighting of the grounds and buildings, this being very much in arrear. Up to the expiry of the first three months the full amount of 8dol. per lamp had to be paid in advance, and claims for rebate on the time of non-supply claimed formally afterwards, but requisitions for light after August were allowed on an advance payment of less than 8dol. per lamp, according to the time for which light was actually supplied."

A further appendix confirms the official report on the Electrical Congress concerning the formal adoption of legal units of electrical measure by different Governments. This report was given some months ago in this journal.

COMPANIES' MEETINGS.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.

The twenty-seventh ordinary general meeting was held last week at Winchester House, Mr. W. S. Andrews presiding.

The **Chairman**, in moving the adoption of the report, said the receipts for the half-year ending December 31, 1893, were £80,538. 18s. 3d., as compared with £86,954. 11s. 2d. in the corresponding period, showing a diminution of £6,600. Remembering the state of things that existed during the half-year in Brazil that was very satisfactory. The remarkable point was that notwithstanding the many interferences with their business which had taken place, there had been no loss of traffic. On the contrary, there had actually been an increase. The diminution in the receipts was consequent upon the unfavourable exchange prevailing in Brazil. The average exchange in the half-year had been 10¾d. against 1s. in the corresponding period, and that record of lowness was being surpassed at the present time, for the exchange now showed a still further reduction. Compared with the par of exchange, they thus lost £20,715, while the Platino Company, the net receipts of which undertaking came to this Company in the shape of dividend, lost during the year £16,563. These two amounts together came to £32,278, or 2½ per cent. on the capital of the Company, so that but for this exceptional state of exchange they could have paid 5 per cent. instead of the 2½ per cent. now recommended. They were adding £5,000 to reserve, and carrying forward a balance of £1,045.

Mr. C. W. Earle seconded the resolution, which was carried after some discussion.

AFRICAN TRANSCONTINENTAL TELEGRAPH COMPANY.

The adjourned ordinary meeting was held last week at 19, St. Swithin's-lane, the Duke of Abercorn presiding.

The **Chairman**, in moving the adoption of the report, stated that from a mail received he learned that the surveyors and contractors for the Salisbury-Tete section had completed their survey, and that the telegraph route was cut over 220 miles, practically the whole distance. The work of cutting this route was very difficult in consequence of the great scarcity of water, and the country was found to be very rocky about 70 miles from Tete. The contractors stated that they would be ready with their party to start the construction at once, if the material were at hand. The delay in its arrival at the western terminus of the Beira Railway, near Chimoio, was, they hoped,

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now overcome, and the material in the course of transit to Salisbury. They relied upon the support of the Government to overcome the difficulties raised by the Portuguese as to the construction of a line within their sphere of influence, and they learned that negotiations were now on foot to promote this end.

The resolution was adopted.

BUSINESS NOTES.

Paddington.—The Paddington Guardians have decided to light the infirmary wards by electricity.

Western and Brazilian Telegraph Company.—The receipts for the week ended May 18 were £2,545.

Brechin.—The Town Council have not yet arrived at a decision as to whether or not to promote a provisional order.

Liverpool Overhead Railway.—The traffic receipts of this railway for the week ended 20th inst. amounted to £1,282.

Dunoon.—The Town Commissioners will shortly meet to consider the question of lighting the Castle gardens by electricity.

Ashton-under-Lyne.—The Town Council have nominated a subcommittee to consider the question of establishing a central station.

Hertford.—The Electric Lighting Committee are enquiring into the probable support of the inhabitants to an electric lighting scheme.

Birmingham.—The City Council will erect a meat market and slaughter-houses in Bradford-street. They are to be lighted by electricity.

West India and Panama Telegraph Company.—The receipts for the two weeks ended May 15 were £1,455 less than for the corresponding period of 1893.

Royal Institution.—The Friday evening discourse at the Royal Institution on June 1 will be delivered by Prof. Oliver Lodge, F.R.S., on "The Work of Hertz."

An Inspector Required.—As will be seen from our advertisement columns, the Commissioners of Sewers of the City of London are about to appoint an inspector under the Electric Lighting Acts. The salary will be £250 per annum.

Stock Exchange Quotation.—The Charing Cross and Strand Electricity Supply Corporation have applied to the Stock Exchange Committee for the vendors' shares Nos. 7 to 214 and 719 to 10,000 to be quoted in the official list.

Electric Motive Power Company, Limited.—This Company has been registered with a capital of £20,000 in £1 shares to enter into an agreement with E. J. Clubbe and A. W. Southey, and to carry on business as electrical and mechanical engineers.

South Staffordshire Tramways.—The petition for the winding up of the South Staffordshire Tramways Company was on Wednesday ordered to stand over till June 13, so that a meeting of shareholders may be called, at which the directors have agreed to tender their resignation.

Messrs. Drake and Gorham.—The lighting of the University Galleries extensions has been given to this firm, who recently carried out the installation at Balliol College, and also Balliol House, at Oxford. There will be about 14 Brockie-Pell arc lamps and about 70 incandescent lamps.

City and South London Railway.—The receipts of the Company for the week ended May 20 were £907, against £794 for the same period last year, or an increase of £113. The total receipts for the first half-year of 1894 show an increase of £477 compared with those for the corresponding period of 1893.

Chiswick.—The Local Board have received a letter from Messrs. Bourne and Grant concerning works for electric lighting in Chiswick, stating that they were anxious to proceed with the works, and were digging at the pumping station to obtain foundations. As soon as they got down to the exact depth they would send in plans to the Local Board.

Brighton.—Three tenders have been received by the Lighting Committee of the Town Council for supplying the alternating-current cable required for Preston and North-East Brighton, together with the necessary joints and boxes. The highest tender is £4,745. 3s., and the lowest £3,579. 6s. The latter is from the British Insulated Wire Company, and has been recommended for acceptance.

West Coast of America Telegraph Company.—The report of the directors for the year ended December 31 last states that the gross income for the year was £15,096, as against £22,218 in 1892, and, in order to make up the loss on the year's working and to meet the debenture coupons, it was necessary to take £16,536 from the reserve. The total expenses were £19,632, against £21,919 in 1892, a saving of £2,286.

Plymouth.—At a public meeting held the other day, Mr. Bond, in reply to a ratepayer who suggested that the water wasted in winter in the borough might be utilised for the purposes of electric lighting, said that the Corporation had been granted a monopoly of the public lighting, and that the water engineer had been directed to report how far the waste of water could be utilised to produce electricity.

Immisch Electric Launch Company, Limited.—This Company has been registered with a capital of €12,000 in £1 shares. The object is to acquire the undertaking of the Thames Launch Department from the General Electric Power and Traction Company, Limited, in accordance with an agreement made by this Company with the General Electric Power and Traction Company, Limited, and to carry on and extend the operations of the same.

Richard Hornsby and Sons, Limited.—The directors have declared an interim dividend on the preference stock at the rate of 6 per cent. per annum, for the half-year ending June 20 next. They propose no interim dividend on the ordinary shares, and in future will pay none, considering it wiser to refrain from distribution, until the stocktaking at the close of the financial year has revealed the true position of the Company.

Southampton.—The Works Committee of the Harbour Board reported last week on a letter received from Mr. Kerbey Bowen, confirming the arrangement as to the supply of electric power to launches, and the wharfinger was instructed to confer with the consulting engineer as to the further cranes required at the quay extensions, etc. Instructions were given for the electric lighting at the pier and pavilion, to be carried out by the Board's own labour.

Engine Fitters.—The Corporation of Cardiff are about to appoint four practical engine fitters for the purpose of taking charge of the engines and plant at the electricity works, Canton, Cardiff, and invite applications for those posts. Applicants must be resident within the borough of Cardiff, practical engine fitters, and not more than 45 years of age. The salary offered is £2. 2s. per week. Applications are to be sent to the town clerk by June 4.

Morecambe.—The Local Board recently interviewed the secretary (Mr. J. Jowett) and the engineer (Mr. T. Preece) of the Morecambe Electric Light and Power Company with reference to the alleged nuisance arising from the company's works. After some discussion, Mr. Preece expressed a desire to go into the matter thoroughly; and it was ultimately agreed that he and the medical officer and surveyor should meet and consult on some occasion when the nuisance was perceptible.

Llandudno.—The Electric Light Committee of the Town Commissioners have had under consideration the draft of the provisional order for the electric lighting of Llandudno submitted by Messrs. Bellis and Kingsland. The committee cannot recommend the Board to agree to the terms of the order, and they are of opinion that the question of electric lighting should stand adjourned for a time, having in view the fact that the constitution of the Board will undergo a change in November next. The Town Commissioners have adopted the minutes.

Brighton Hotel.—When the shareholders in the Brighton Grand Hotel Company met last week, the chairman (Mr. Van Tromp) stated that the report of an enquiry committee contained no attack whatever upon the directors, except, possibly, a want of judgment with regard to the electric lighting. If it was desirable to take the light from the Corporation, the directors would be the first to support the suggestion; but after the economies going on, showing a saving of £600 or £700 a year already in generating it on their own premises, it would be as well to continue the present installation.

Ruston, Proctor, and Co.—The report of the directors to March 31 states that the trading results for the year, including a balance brought forward of £4,613, show a balance of £48,940, from which has been deducted for depreciation of plant and machinery, office furniture, directors' remuneration £4,409, leaving £44,531; out of this there has been paid the interest on the debentures and interim dividend of 5s. per share (£18,750), leaving a net balance of £25,781. The directors propose to devote £10,000 in reduction of goodwill account and to pay a dividend of 10s. per share, making 7½ per cent. for the year, leaving a balance to be carried forward of £3,281. 4s. 8d.

Tenders for Bedford.—As notified in our advertisement columns, the Corporation of Bedford invite tenders for the construction, supply, and laying down of the necessary plant and mains for the supply of electricity in the borough. The contract will be divided up into two sections—(1) construction, supply, and erection of boilers, steam-engines, gas-engine, economiser, feed-pumps, condenser, alternators, and switchboards; (2) supply and laying down of transformers and mains. Specifications may be obtained from and plans may be inspected at the office of F. H. Medhurst, M.I.E.E., 13, Victoria-street, Westminster, S W. Tenders are to be delivered by June 16.

Hampstead.—The Vestry have approved of the forms prepared by the Electric Lighting Committee with regard to the supply of electricity by the Vestry to private consumers. There are two forms, the first giving information concerning the electric light and application for supply, and the second being an agreement for supply, with rules for supply and regulations for installation work. The Vestry hope shortly to be prepared to supply electricity in the compulsory area in the parish. A cheque for £120 has been drawn in favour of Mr. W. H. Preece on further account for commission on the amount certified in connection with the erection of the central electric supply station.

New Brighton.—An electric light supply has been installed at the Palace, New Brighton, Liverpool. The installation comprises a gas-engine, which drives a 300-light dynamo, and two pumps, which supply the building with spring water. The plant is fixed in the grotto and open to the public. The grotto is lighted by about 30 16 c.p. lamps, and the dancing hall is illuminated from upwards of 20 electroliers. The skating rink, aviary, and theatre are also electrically lighted. Outside the Palace there are arc lamps. One of the most attractive features of the open-air display is the signboard illumination, which is a construction of different coloured lamps, switched in and out automatically, and alternately showing in all about 20 different combinations of colour.

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Salisbury.—The Town Council held a special meeting last week to consider a communication from Mr. W. H. Gramshaw relating to the proposed formation of a company to supply electric light within the city. The town clerk read the application, which asked the consent of the Council to a provisional order to be applied for to the Board of Trade before July 1. It appeared that the promoters of the company had obtained the freedom of acquiring from the Dean and Chapter the Old Town Mill for the purpose of providing motive power. After some discussion, during which a general opinion was expressed in favour of the scheme, the meeting was adjourned for a week in order to test public feeling on the matter, and to obtain from Mr. Gramshaw fuller information with regard to the proposed undertaking.

Douglas Bay Tramway Company.—An extraordinary general meeting of the shareholders of the Douglas Bay Tramway Company was held on Monday, to pass a resolution to voluntarily wind up the Company and to appoint a liquidator for that purpose. The Company has been bought up by the Douglas and Laxey Electric Tramway Company, who in completion of their purchase paid £18,000 on May 1 to the representatives of the shareholders of the old Company, the balance of the purchase-money being taken in shares in the new company. The proceedings on Monday were formal—the passing of a formal resolution being necessary in order that the £18,000 lying at the bank to the credit of the old company might be distributed amongst the shareholders. The statutory meeting requisite to confirm the meeting is fixed for June 13.

Accepted Tenders.—The following tenders were received by the Brighton Corporation for the supply of motor alternators, transformers, meters, etc.:

J. Fowler and Co., Limited, Leeds	£5,147	0	0
Manchester Edison-Swan Company, Manchester	3,940	0	0
Siemens Bros. and Co, Limited	2,560	0	0
Brush Electrical Engineering Company, Limited	2,450	0	0
Easton, Anderson, and Goolden, Limited	2,125	0	0
Crompton and Co., Limited	2,110	0	0
Electric Construction Company, Limited, Wolverhampton	1,731	17	0

The tender of the Electric Construction Company has been accepted.

Bournemouth.—At a meeting of the Lighting Committee of the Town Council a letter was read from the Bournemouth Electric Supply Company, Limited, giving notice of their intention to give a continuous supply of energy in certain streets, and another letter from the same company was read, enclosing statement of the company's accounts for the year ending December 31, 1893. A letter from the Board of Trade was read, enclosing copy of correspondence with the electric supply company and a report by Major Cardew, R.E. The letter and enclosures have been referred to the surveyor to report upon. The town clerk reported that the Board of Trade had issued the electric lighting license, and the surveyor has been instructed to report on the power at his disposal for electric lighting purposes, and generally on the subject, with estimates. He has been authorised to engage assistance at a cost not exceeding £10. 10s.

Belfast.—The Electric Lighting Committee of the Town Council met last week, when Mr. M'Cowen, the resident electrical engineer, submitted a report on the progress of the works since the last meeting. Plans and specifications for the central station, which had been received from Prof. Kennedy, were examined, and it was agreed to advertise for tenders for the carrying out of the work. Several applications for electric light were received from parties outside the area of supply, and the committee decided to grant these if the applicants complied with the electric lighting order, and entered into written contracts to continue to receive and pay for the supply of energy for at least two years, of such an amount that the payment to be made for it at the rate charged to consumers within the area should not be less than 20 per cent. of the outlay incurred by the Corporation in providing the electric lines for such purpose beyond 60ft. from the proposed distributing main.

Glasgow.—The Works Committee of the Clyde Trust have had under consideration for some time the question of the lighting and providing of crane accommodation for the new Cessnock Dock In December last a report was submitted to the committee, containing information collected on visits to English and continental ports regarding electrical and hydraulic appliances. In view of the recommendation in that report that tenders be taken for an electric light installation to light the dock and work nine cranes on the south quay of the north basin, the sub-committee were directed to take tenders for nine 35cwt. hydraulic cranes and installation for working the same, and alternatively tenders for nine 35cwt. electric cranes and installation. The committee accordingly procured 12 tenders for hydraulic power installation, and 20 for electric power installation, but none of the tenderers, though requested, furnished any data as to the cost of working and maintenance. An examination of the tenders showed that the first cost of the electric installation would be much greater than hydraulics, and this fact led the committee to recommend the adoption of a hydraulic installation for this part of the dock.

The Telephone System.—The report recently circulated that all the numbers of telephone subscribers were to be changed induced a *St. James's Gazette* representative to call at the offices of the National Telephone Company to enquire the cause of so radical an alteration. He was at once informed (says our contemporary) that the rumour had scarcely any foundation), the fact being that of all the thousands of subscribers only 500 would be affected. The change was unavoidable, being due to a rearrangement of one of the exchanges; but it would not interrupt the working of a single line. There are 70,000 subscribers in England, Scotland, and Ireland, 7,500 of whom are in London. These necessitate the keeping up of 540 exchanges, 25 of them being metropolitan. There are 1,283 public call offices, and 245,000,000 messages are despatched every year. The area of the London district covers upwards of 500 square miles. In future every line in London will be composed of a metallic circuit necessitating two wires. This alteration is rapidly being carried out without any interruption in the working of the lines affected. The National Telephone Company are at present completing in Lime-street the largest exchange in England. It is being built on a scale to accommodate 7,600 lines when fully occupied.

The Dover Central Station.—The question of lighting Dover by electricity has been before the Town Council for about 10 years. When the question came to be tackled at close quarters it was felt that the enterprise was too delicate for the Corporation to handle, and it was ultimately decided to transfer the powers of the provisional order to the Dover Electric Supply Company, which was formed last autumn with an authorised share capital of £50,000, the new company being assisted into existence by the Brush Electrical Engineering Company, who previously had the matter in hand, and who have entered into a contract to supply the electrical equipment. The company purchased the site of the station on the east of Park-street, and a contract was entered into with Mr. Herbert Stiff to erect the new station now in progress. The land secured for the station runs the whole length of Park-street, and adjoins the grounds of Brook House on the other side. The main building is 116ft. long and 72ft. wide; the boiler-house is 100ft. long and 42ft. wide; the machine-room is 100ft. long by 30ft. wide. There are also a testing-room, a Board-room and office, cloakroom, and lavatories. The boiler flue runs along the floor to the upper end, where it joins the base of the chimney. The contract for the whole of the building has been taken, as already mentioned, by Mr. Herbert Stiff, who has to finish it by August 13. The oversight of the work is entrusted on behalf of the Dover Electric Supply Company to Mr. Alfred Matthews, formerly a member of the Dover Town Council.

Ealing.—At a meeting of the Local Board last week, the Electric Lighting Committee reported that they had visited the electric lighting works, and expressed their satisfaction with the progress the works were making. The surveyor mentioned to the Board that a number of houses in the district, including two in the Grange-road (Beaumont House and Garth House), and others in Hanger-lane, had been, or were about to be, wired. In answer to a question the surveyor said that whether an installation of the light could be made in Mount-park and that neighbourhood would depend upon the number of householders in that vicinity who signified their willingness to take the light. The surveyor read a letter from a resident of Park-hill asking whether any steps were likely to be taken towards the introduction of the light into that locality, and suggesting the issue of a circular to owners and residents of property in the district as a means of ascertaining what amount of private lighting was likely to be required. This suggestion was adopted by the Board, and a resolution was passed directing the issue of a circular stating the cost of the new light, and asking whether its installation for the purposes of private lighting would be needed. The Board had again under consideration the draft of the conditions to be observed in the wiring of private premises for the supply of the electric light, and fixing the charge to be made for rent of meters and current. The former charge was 1s 6d. per quarter for any number of lamps up to 25 lamps of 8 c.p. each, with a fixed increase per quarter for every additional 25 lamps beyond that number; the charge for current was at the rate of 6d. per Board of Trade unit. These conditions and charges were approved. The Board then proceeded to discuss the question of the position in which the public street lamps to be erected under the electric lighting scheme should be placed along the main road from the western end of the Broadway (not including that thoroughfare itself) to the Hanwell boundary of the district.

Electric Lighting of St. Paul's Cathedral.—Major-General Webber has sent the following letter to the *Daily Telegraph*: "In your issue of this date I observe that you describe the experiment of lighting St. Paul's Cathedral on the 11th inst. as a 'dismal failure,' and 'that the distribution of light was irregular and insufficient'; also that 'the intensity of the shadows is said to have been positively gruesome.' As responsible, under the committee of the cathedral authorities, I may be regarded as the 'skilful electrician' who was consulted, and, therefore, trust you will permit me to correct the misapprehension under which your informant must have laboured. The experiment to which he refers was one of a series which have been made this year, the object of which has been to arrive at several conclusions on the question of cathedral lighting that have hitherto been obscure. Their objects have been to test (1) the comparative value of the arc and of the incandescent lamp as an illuminant in places used for public worship, especially with reference to the absorption of light by the stonework of St. Paul's; (2) the possibility of giving sufficient light, without standards or pendants, so that every individual in the congregation occupying so large a space as that under the dome of St. Paul's could read small print with ease, and also to ascertain the volume of light required to give that result; (3) the possibility at the same time of placing the light so that it would fulfil two conditions—namely, so that the glare of the incandescent portion of the lamps should not offend the eyes, either of the congregation looking eastward or of the occupants of the choir and chancel looking towards the west. It was proved conclusively by the experiments that these

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difficult but essential conditions could be attained without cross shadows, and that the illumination was most regular and adequate within the area dealt with—namely, the floor space under the dome. A few other tests were made in isolated portions of the cathedral from which the general results, on a more extended scale, could be estimated, and possibly your informant was unintentionally misled by the partial character of those results (quite understood by the committee) into adversely criticising arrangements which, if permanently reproduced on an extended scale, will place our metropolitan cathedral in front of all other ecclesiastical edifices as the great example of how electricity as an illuminant can be applied artistically, scientifically, as well as economically."

Electricity in Mining Operations.—Messrs. Ernest Scott and Mountain, Limited, electrical and general engineers, Close Works, Newcastle-on-Tyne, have just completed for the Lothian Coal Company two large sets of electric pumping machinery, and a third set is to be added shortly. The present plant consists of two dynamos, each to give an output of 60,000 watts; two sets of three-throw ram pumps, each set to be capable of delivering 250 gallons of water per minute against a head of 650ft., each set to be driven by an electric motor of 60 h.p. Heavy-armoured cables are being used for conveying the current from the engine-room at bank to the pumps, which are placed underground. The same firm have in hand for Messrs. G. B. and T. E. Forster, for Cambois Colliery, Northumberland, seven sets of electric pumping machinery. The plant consists of horizontal engine, with triple expansion gear capable of developing 80 h.p., and a 50-unit Tyne shunt-wound dynamo working at an E.M.F. of 350 volts, together with conducting cable from the dynamo to the bottom of the shaft, with branch cables to the seven sets of pumps. This plan is interesting inasmuch as it is the first case in which electricity has entirely replaced rope-driven pumps, and particularly as the old pumps have been used, each pump being driven by an 8-h.p. electric motor through worm gear. The crankshaft on which the worm-wheel is placed takes the same position as the old shaft on which the wire rope was fitted. There is about 20 miles of cable in all underground leading to the various pumps. Each circuit, which is controlled from a junction-box, is fitted with a switch, so that the pumps can be stopped and started from various points. The same firm have in hand for Messrs. Strakers and Love a set of electric pumping machinery, consisting of horizontal engine of 125 i.h.p., a 55-unit Tyne shunt-wound dynamo, with overhead conducting cables, and a set of three-throw pumps, with rams 9in. diameter and 15in. stroke, delivering 300 gallons of water per minute through two miles of 6in. pipe, total head, including friction, being 420ft. In this instance a Tyne electric motor of 55 effective horse-power is used for driving the pumps. In the electric light department the firm are also extremely busy, and have in hand the lighting of the Edinburgh Roperie, with engine, dynamo to run 600 lights, and incandescent lamps throughout the Roperie. In a large private house in Kirkby Lonsdale, being built by Dr. W. T. Paget-Tomlinson, the plant consists of a Priestman oil engine of 22 h.p., a dynamo to run 200 lights, with accumulators, and about 260 lamps throughout the house. They have just completed for the Coltness Iron Company an installation consisting of three dynamos, two machines being used for lighting the pithead and workmen's cottages, the third for an electric pumping plant, the pumps being placed by the river and capable of delivering 120 gallons per minute against a head of 160ft. Lighting installations are being carried out by them at Shaw's Hotel, Grisland, for the s.s. "Aswanley," and at Seaton Delaval Colliery, together with an installation for Messrs. Jonas Brook and Bros., Feltham, which is just completed, consisting of two 800-light dynamos, and 1,400 incandescent lamps. In the engineering department the firm are busy, having in hand a large number of fire and bilge pumps for the torpedo destroyers, together with other engineering specialities.

Action for Telephone Rental.—On Wednesday, at the Sheffield County Court, before Judge Ellison, an action was brought by the National Telephone Company against Messrs. Morris and Matthew, chemical manufacturers, Doncaster and Stockwith-on-Trent, to recover £50, balance of rent due for telephone service. Plaintiffs were represented by Mr. T. E. Ellison (instructed by Messrs. Webster and Styring), and Mr. B. G. Wilkinson (instructed by Messrs. Parkin and Co., Doncaster), appeared for the defendants, who had filed a counterclaim for £50 damages arising from the defective working of the telephones. Defendants do not deny that the rent sued for was due under the contract between themselves and the plaintiff company, but they contended plaintiffs were not, under the special circumstances, entitled to it. Mr. Wilkinson, on behalf of the defendants, explained that in 1889 his clients were approached by the company with reference to putting up a telephone wire between their offices in Doncaster and their works at West Stockwith, about 20 miles away, and also a wire between the offices and the residence of Mr. Morris, the senior partner, who lived in the suburbs of Doncaster. The plaintiff company sent the contract to the defendants for signature, and with it was a letter in which the company stated, amongst other things, "We guarantee that the communication between your offices and works will be absolutely satisfactory to you, and that any repairs, should there be any, will be attended to at once by the company." It was on the faith of that strongly-worded assurance that defendants signed the agreement in March, 1889. Although it was said the wires would be laid in a few weeks, 12 months elapsed before the work was completed, and it was not until March, 1890, that the defendants were placed in possession of the service. From the very commencement the defendants were subject to great annoyance because of the imperfectness of the communication. In consequence of this the company allowed a deduction of £10 on the rental for the first year. During the succeeding three years the communication continued to be most unsatisfactory, and complaints were constantly made to the company—in fact, no less than 118 letters calling attention to this and requesting a remedy were sent—but with no result. Two years ago, or thereabouts, the company put up public wires for parties in other places on the poles used for defendants' private wires, and this added to the confusion, inasmuch as when defendants wished to speak from their offices to the works they would be interrupted by conversations between persons in Sheffield, Gainsborough, and other places. Defendants' contention was that the work in connection with laying down the telephonic service was unskilfully done. The company had almost continuously sent men to effect an improvement, but they did not succeed, and defendants' business was interfered with. Counsel went on to contend that the contract between defendants and plaintiffs was made from a company point of view, and that defendants, as business men, would not have signed such a one-sided document unless they had had some distinct assurance from the company such as was contained in the letter that the service would be satisfactory, and he contended that the guarantee became part of the contract. Several witnesses having been called on behalf of the defendants, all of whom bore out counsel's opening statement, it was intimated that to finish the case would occupy a long time, and it was therefore agreed to adjourn the further hearing to a date to be fixed.

A New Underground Conduit.—Mr. John Wilkinson, of 27, Rawcliffe-street, South Shore, Blackpool, who for nine years was a member of the Blackpool Town Council, has devised a system which he anticipates will prevent a recurrence of the annoying delays arising on electric tramways in consequence of accumulations of sand, soil, and sea-water, and the overflowing or bursts of the water-mains, resulting in the corrosion of the insulators and continual fusing, and short-circuiting in connection with the underground parts of the conduits or channels, which in time leads to the destruction of the electrical parts, also causing serious irregularities to the dynamos, engines, and other machinery at the works, and a stoppage of traffic until the necessary remedial measures have been taken. Through the slot or groove in the central channel there is refuse constantly entering, but he considers his invention a very feasible one, inasmuch that the conductor and the vital parts of the collector are both protected from injury from the causes mentioned above. An overhanging flange in the central channel covers the conductor and a part of the collector. We quote the following from a Blackpool paper: "Instead of the box which has now been introduced under Mr. Holroyd Smith's scheme, Mr. Wilkinson has made provision for an 'inner box rail.' The rail provided for by Mr. Wilkinson is rather broader than that at present in use. Within this rail is an 'inner box rail' made of handy and convenient lengths, so that it may easily be removed for examination of the conduit and the restoration of any of the electrical appliances. Under the old arrangement, in order to repair the conductor or to open the central channel, a large length of rail had to be removed. These operations have, under Mr. Wilkinson's scheme, been very greatly facilitated. The lengths can be easily taken up, and the whole of the mechanism and apparatus is at once exposed to view, so that any repairs can be carried out without any interference with the traffic. Of course the great feature of the design is the effect it is expected to have in combating the evils of accumulation of dust, but the dispatch with which repairs can be effected is also a very great point in its favour. The channel provided for is exactly similar to that of the Blackpool tramways, so that in case the necessity ever arose for the trial of a new system—a not very improbable emergency—if regarded favourably, Mr. Wilkinson's scheme might be adopted without any very great alterations. The copper conductors can be replaced in a very short time. The insulators are equally easy of access, and very little work is entailed in the substitution of new ones for those that may be broken, or in any way defective. The ex-councillor claims that his invention is especially adapted for the Blackpool Promenade; he maintains that it is a great advantage to be enabled to inspect the mechanism at any given point, and not at intervals as provided by a box system. Under his scheme, he points out, the whole of the line might be opened concurrently in order that repairs might be carried on with freedom, or the channel cleared without interference with the progress of the cars. But beyond this Mr. Wilkinson is considering the advisability of providing for a double conductor, one of which would be kept in reserve. He argues that this would be a great safeguard in regard to accidents or defects, for when one conductor failed the other conductor could be utilised, and it would not be necessary to suspend traffic at all. For several months past the inventor has had the matter under consideration, and he intends to submit his model to the Blackpool Corporation, in the hope that if there are further developments in connection with the tramways, a trial may be given to a scheme which he considers would be voted a success."

The Wolverhampton Central Station.—The Mayor of Wolverhampton (Alderman C. T. Mander) on Monday laid the foundation-stone of the municipal electric lighting works, which are situated in Commercial-road. The proceedings were of a formal character. Among those present were Aldermen W. H. Jones and J. Sanders; Councillors Shepherd, Jenks, Johnson, and J. J. Tate; and Messrs H. Brevitt (town clerk), T. Parker, F. H. Lewis (electrical engineer), A. P. Brevitt (architect), H. Willcock (builder), and J. T. Homer. The Mayor was presented by Mr. Brevitt with a silver trowel, bearing the following inscription: "Presented to the Right Worshipful the Mayor of Wolverhampton (Mr. Alderman Charles Tertius Mander, J.P.), by the architect, Archibald Paul Brevitt, on the occasion of his laying the foundation-stone of the Municipal

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Electric Lighting Works, on Monday, the 21st of May, 1894." Subsequently the Mayor entertained a number of gentlemen to luncheon at the Victoria Hotel, and after the toast of "The Queen" had been honoured, his worship proposed "Success to the Electric Lighting Works of the Wolverhampton Corporation." He said the question of introducing the electric light into Wolverhampton was mentioned some years ago, but it was delayed by the Town Council, and probably no one was any the worse for the matter having been proceeded with slowly, inasmuch as during the last few years great strides had been made in the study of electric lighting, and by waiting the Wolverhampton Corporation had probably been able to introduce a system which they could not have initiated even four or five years ago. The plant which would be put down would be capable of generating sufficient current for 10,000 lamps, and this number could be increased to 15,000. There was a difference of opinion as to the relative cost of gas and electricity, but he believed that electric lighting was practically no more expensive than gas at 2s. 9d. per 1,000ft., and in the near future it would be less costly. Alderman W. H. Jones then submitted the toast of "The Architect, Builder, and Electrical Engineer, and Mr. Thomas Parker," which was responded to by those gentlemen. The capital outlay in connection with the cost of the undertaking is something like £30,000, and the parts of the town proposed to be lit up at the beginning are Darlington-street, Waterloo-road, Victoria-street, North-street, Cheapside, Exchange-street, Queen-square, Dudley-street, Snowhill, Lichfield-street, Princes-street, Five-ways, Queen-street, and the western end of Bilston-street. The boiler-house, which adjoins the engine-room, is to be 50ft. long, and the engine-house 78ft. long by 55ft. wide. The stack, circular in shape, will be 120ft. high. The contract for the buildings is in the hands of Messrs. H. Willcock and Co. Wolverhampton. The new buildings will occupy 1,330 square yards of land, in an area three times the size, which has been provided for the purpose, so that there will be plenty of room for any extension that may be required. In the boiler-house will be placed three Lancashire boilers, 30ft. long by 8ft. diameter, and they will be fitted with Green's economisers, while in the engine-house there will be placed one 125-h.p. and two 250-h.p. compound condensing engines. The smaller engine will drive by ropes a dynamo capable of supplying about 2,000 8-c.p. lamps, and the larger engines will similarly operate two dynamos, which will each be capable of supplying current for about 4,000 8-c.p lamps. The condensing-room will contain an Edward's ejector condenser and a Stanhope Water Engineering Company's water softener. The work of laying the mains has been commenced. The current generated by the dynamos will be sent under high pressure to the Town Hall, where the vault beneath the sessions court will be set apart as a central switch station, whence the current will be distributed under low pressure to sub-stations at the art gallery and free library. It has been decided to charge 6d. per unit.

PROVISIONAL PATENTS, 1894.

MAY 15.

9534. **An improved device for use with current meters, in observing the charging and discharging of electric accumulators.** Adolf Kolbe, 6, Lord-street, Liverpool.

9540. **Improvements in or relating to incandescent electric lamps.** Arthur Hungerford Pollen and Alan Donolly, 323, High Holborn, London.

MAY 16.

9565. **Improvements in the metal screw, belt, or other attachments for fixing insulators to carry electric wires.** Avon Gray, Featherstone-road, King's Heath, Birmingham.

9605. **Improvements in electric machines.** William Morris Mordey, 46, Lincoln's-inn-fields, London.

MAY 17.

9627. **Improvements in the mechanism of arc lamps.** Charles Neal Dexter, 114, Campsbourne-road, Hornsey, London.

9647. **Improvements in and connected with telephones.** James Nicolson, 22, Glasshouse-street, Regent-street, London.

9673. **Improvements in means for the distribution of alternating electric currents.** David Cook, 30, Lancaster-park, Richmond, Surrey

9690. **An improved electrical device for facilitating the lighting of gas.** Jean Jahnsson, 11, Southampton-buildings, Chancery-lane, London. (Complete specification.)

MAY 18.

9743. **Improvements in electric conductors principally designed for lighting and heating purposes.** Ernest Bailey, 45, Southampton-buildings, Chancery lane, London.

9761. **Improvements in electrolytic apparatus.** Thomas Craney, 45, Southampton-buildings, Chancery-lane, London. (Complete specification.)

MAY 19.

9763. **A horary meter for electric light, air, gas, water (compressed or not), and motive force.** Paul Cadot and Albert Charron, Bonnay-Charente, France. (Complete specification.)

9813. **Improvements in or applicable to meters or apparatus for supplying electricity, gas, or other substances in exchange for coin.** Percy Ruskin Allen, 46, Lincoln's-inn-fields, London.

9762. **Improvements on arc lamps.** James William Rogers, 7, Hargrave-park, Upper Holloway, London.

SPECIFICATIONS PUBLISHED.

1881.

2989. **Transmitting power by electricity.** Hopkinson. (Second edition)

1882.

4419.* **Electric arc lamps.** Brockie. (Amended specification.)

1890.

10595. **Measuring electrical energy.** Thomson. (Second edition.)

1893.

7594. **Electrolytical decomposition of chlorides, etc.** Lyte. (Second edition.)

8881. **Electric machine.** Howard.

9638. **Telephone apparatus and circuits.** Hall.

9639. **Telephone signalling apparatus and circuit.** Hall.

9640. **Electrical signalling apparatus and circuits.** Hall and Pickernell.

9753. **Electrical measuring instruments, etc.** Ayrton and Mather.

10396. **Electric conductors.** Dudgeon. (Société Anonyme John Cockerill.)

11842. **Electrical conductors.** Payne.

11890. **Telephones.** Rabbidge.

12437. **Electrically controlling lubricators.** Rosling and Matthews.

13491. **Semaphore signal apparatus.** Siemens Bros. and Co., Limited. (Siemens and Halske.)

13492. **Operating signals by means of passing trains.** Siemens Bros. and Co.. Limited. (Siemens and Halske.)

13996. **Vehicles and electric locomotives for elevated railways.** Behr.

20887. **Incandescent lamps.** Ford and Barnes.

21379. **Electric light for photographic purposes.** Adamson.

1894.

4091. **Electric arc lamp carbons.** Jehl and Von Hardtmuth.

4333. **Suspending electric light, etc., fittings.** Johnson.

4909. **Targets and electrical indicating apparatus.** Collins and Jones.

5276. **Electric railways.** Cummins and Engelman.

5807. **Electrical safety fuse.** Edison and Swan United Electric Light Company, Limited, and Proctor.

COMPANIES' STOCK AND SHARE LIST.

Name.	Paid.	Price Wednesday.
Birmingham Electric Supply Company	5	5¼-5⅜
Bournemouth Electric Company	—	—
Brighton and Hove Company Original	100	210-215
Brush Company, Ordinary	3	2¾-3
—— Nom. Cum , 6 per cent. Pref.	2	2¾-2⅞
—— 4½ Debenture Stock	100	108-111
Charing Cross and Strand	5	4½-5
Chatham and Rochester	—	—
Chelsea Electricity Company	—	—
City of London, Ordinary	10	12-13
—— 6 per cent. Cumulative Pref.	10	12½-14
—— 5 per cent. Debenture Stock	75	82-85
City and South London Railway, Consolidated Ordinary	100	81-83
—— Debenture Stock	100	113-115
—— 5 per cent. Pref. Shares	10	11½-11⅝
Crompton and Co., 7 per cent. Cum. Pref. Shares	5	3-3½
—— 5 per cent. First Mortgage Debentures—1-400 of £100 and A, 1-200 of £50	100	95-100
Elmore's French Company	2	1-1⅛
Electric Construction, Limited	2	1-1⅛
—— 7 per cent. Cumulative Pref.	2	1⅝-1¾
Elmore's Copper Depositing	2	1⅝-1¾
Electricity Supply Company for Spain	5	—
Elmore's Wire Company	2	1-1⅛
Fowler-Waring Cables	5	1-1⅛
W. T. Henley's Telegraph Works, Ordinary	10	6¾-7¼
House-to-House Company	5	1-1⅛
India Rubber and Gutta Percha Works	10	2¾-3¼
—— 4½ per cent. Debentures	100	103-105
International Okonite, Ordinary	10	1-2
Kensington and Knightsbridge	5	4¾-5⅛
Liverpool Electric Supply, Ordinary	5	6¾-6⅞
—— Pref.	4½	5-5⅛
Liverpool Overhead Railway	10	8¾-9⅛
—— 4 per cent. Mortgage Debentures of £100	100	110-112
London Electric	5	1-1½
Metropolitan Electric Supply	10	7½-8
—— 5 per cent. Reg. Debentures, 1-10,000 in Bonds of £10, £20, and £40	—	108-111
National Telephone, Ordinary	5	4¾-5⅛
—— 6 per cent. Cum. First Pref.	10	15-16
—— 6 per cent. Cum. Second Pref.	10	14½-15½
—— 5 per cent. Nom. Cum. Third Pref.	5	5⅛-5⅜
—— 4½ per cent. Deb. Stock	—	114-116
Notting Hill Company	10	4¾-5⅛
Oriental and Electric Company, £1 shares	1	1-1⅛
Southampton Electric Company	—	—
St. James's and Pall Mall, Ordinary	5	6¾-7¼
—— 7 per cent. Pref.	5	6¾-7¼
Swan United	24	15-16
Telegraph Construction and Maintenance	12	10-11
—— 5 per cent. Bonds	100	104-107
Westminster Electric Supply, Ordinary	5	6¾-7¼
Yorkshire House-to-House	4½	4¾-5⅛

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NOTES.

The Bebe.—Our contemporary *Electricité* refers to the infant dynamo as a bébé.

Hotel-Lighting.—The Royal Palace Hotel, Kensington, is lighted throughout by electricity.

Electric Lighting at Gross-Becskerek.—It is proposed to light this Hungarian town electrically.

The Blackpool Tramway.—It is expected that the electric working of the tramway will be resumed very shortly.

Electric Lighting at Faverney.—This town of 1,500 inhabitants, in Haute-Saône, is to be lighted electrically.

Tolz-Krankenheil.—The streets, the Kur Hotel, the Hotel Sedlmair, and the Hotel Artman at this health resort are now lighted electrically.

Valence.—The Municipal Council of Valence, in the Drome district, has been approached with a view to an electric lighting concession being granted.

Charing Cross-Hampstead Railway.—The Charing Cross, Euston, and Hampstead Railway Bill has been read a third time in the House of Commons.

Borneo.—The British North Borneo Company have decided to connect the capital of their territory, Sandakan, by telegraph across country, a distance of over 200 miles.

Electric Tramway at Lubeck.—The opening is announced at Lübeck of an electric tramway. It has been constructed by the General Electricity Company of Berlin.

Not the "Electrical Engineer."—A contemporary asks those firms who gratuitously receive two copies of its issues to kindly give intimation of the fact to the publishers!

Porrentruy.—Two companies are desirous of undertaking the supply of electricity to this industrial town in the canton of Berne. The Municipality are enquiring into the matter.

Current for Motive Purposes at Altona.—The Altona Electricity Works have reduced their charge for current for motive purposes to 2·5pf. per 100 watts—or, say 3d. per unit.

Exhibition at Dover.—An electrical exhibition was held at the Municipal Buildings, Dover, on Friday and Saturday last, in connection with the introduction of the light into Dover.

The Brussels Tramway Company.—The receipts of this concern have increased considerably since the introduction of electric traction on the Uccle line and on the outer boulevards.

Competition.—The town of Arad (Hungary) invite by July 1 tenders for the erection and working of a central station. Particulars may be obtained of M. Salaez Gyula, the mayor of Arad.

Electricity at Ulm.—Messrs. Schuckert and Co., of Nuremberg, have received a 50 years' concession for the construction and working of a central electricity station and a tramway line.

Conversazione.—A students' conversazione was held at the City Guilds of London Institute, Leonard-street, on Thursday evening of last week. Prof. Silvanus Thompson delivered a lecture on "Polarised Light."

Electric Lighting at Havre.—The General Council of Havre have decided that the local electrical company shall be asked to light various streets and squares in the town by means of 80 10-ampere arc lamps.

A New Mitrailleuse.—It is reported that M. Turpin has devised a light mitrailleuse, worked by electricity, and with such rapidity that it can be charged and scatter balls as thick as hail in the twinkling of an eye.

Telephony and Telegraphy in Belgium.—The *Journal Télégraphique* of May 25 contains a large amount of statistical information concerning the working of the telegraphs and telephones in Belgium during 1892.

Electric Lighting in Frankfort-on-the-Maine.—Good progress is being made in connection with the erection of the municipal central electric lighting station. It is expected that it will be in working order by October 15.

Institute of Chemistry.—The annual dinner of the Institute of Chemistry of Great Britain and Ireland took place at St. James's Hall on Friday evening, Dr. W. J. Russell, F.R.S. (president of the institute), being in the chair.

Rock Drills.—Mr. J. S. Martin, H.M.'s Inspector of Mines for the South-Western District, suggests in his annual report that it is desirable for mineowners to give consideration to the operation of rock drills by electric power.

Thomson-Houston Company.—The Compagnie Française pour l'Exploitation des Procédés Thomson-Houston have decided to increase their share capital from £40,000 to £200,000 by the issue of 8,000 new shares of £20 each.

Water Power.—The works in course of construction at Chambéry for the utilisation of water power are being energetically pushed forward. The power available amounts to 1,400 h.p., this being in excess of that required for electric lighting purposes.

Graz.—Work is being energetically carried out in the laying of mains and the building of the central station, which it is expected will be completed at the latest by October. The new university buildings will have 1,000 incandescent lamps installed.

Electric Lighting at Weisswasser.—A central electric light station, which is being erected here by Messrs. Schuckert and Co., will be completed by September. The prices to be charged are 6·5pf. for lighting, and 2pf. for motive purposes per 100 watts.

Railway Station-Lighting in France.—The Northern Railway Company are installing the electric light at their stations at Albert (Somme) and at Cambrai (Nord). At the latter, two Breguet dynamos will be used, requiring steam power of 100 h.p.

Long-Distance Telephony in Germany.—Telephonic communication has been established between Hamburg and Hanover. The charge is 1s. for three minutes' conversation. For urgent messages the charge is thrice as much for the same period.

Economy of Electric Motors.—Mr. W. H. Panton, of Messrs. Dorman, Long, and Co., confirms the statement made by Mr. Bigge, referred to in another column, that the application of electric motors to their lighter machinery has saved his firm 30 to 35 tons of coal per week.

Electric Lighting at Montferrat.—The Municipal Council of this French town of 620 inhabitants have approved of an electric lighting scheme submitted by Messrs. Souchier and Co., of Marseilles. The municipal lighting is to comprise 14 16-c.p. lamps in the streets.

Traction in Switzerland.—The scheme for the construction of electric tramways at Chaux-de-Fonds has been deferred for the moment, so as to allow of a decision being arrived at concerning the proposed utilisation of the water

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power of the Reuse for the operation of the generating plant.

Steam Traction.—We note that a company has now been formed in Paris under the title of the Société des Générateurs à Vaporisation Instantanée, système Serpollet, with offices at 27, Rue de Cloys, to operate tramways on the Serpollet steam traction system in competition with electric tramways.

Electric Traction at Hamburg.—Surveys are being made in connection with the high-level electric railway which was sanctioned some time ago, and which is to run from the Berlin Gate in Hamburg to the Victory monument at Altona. The line will in part be carried over the roofs of the houses.

Yet Another Exhibition.—Next year there will be held in Leipzig the seventh triennial exhibition of the metal goods, plate, and lighting industries. Particulars are obtainable from the Bureau für die VII. Allgemeine Fachausstellung des Verbandes Deutscher Klempner-Innungen, 6 Inselstrasse, Leipzig.

The Neuhausen Aluminium Works.—The result of the past year's working of this Company is very satisfactory. At the annual general meeting held lately at Frankfort-on-the-Maine a dividend of 10 per cent. was declared. It has been agreed to raise the capital of the Company from £400,000 to £440,000.

Electric Railway in Denmark.—Application has been made to the Government for a concession for an electric railway between Klampenborg and Humlebök on the Sound, which places are about 16 miles apart. The line is intended chiefly for passengers, but it is also proposed to carry a limited amount of goods.

The Land of Bliss.—The Americans have a lot to boast about, and so have we; but if the Metropolitan Traction Company of New York introduce, as is stated, the conduit system as employed at Budapest, this will show that even in electric traction our American friends do not "lick creation" when they have to come to Europe for an open-conduit system.

Northern Society of Electrical Engineers.—We are glad to learn from our New York namesake that the Northern Society of Electrical Engineers is seeking recruits in the United States. At all events, that is the conclusion we have arrived at from the fact that the rules, list of members, etc., have reached the United States before they have arrived in the Metropolis.

Feldkirchen (Carinthia).—An electric installation for 500 incandescent lamps simultaneously alight is to be carried out here. There will be two central stations working on a joint system of conductors. The stations will be about 900 yards distant from each other. There will be a 25-h.p. turbine at each. The work is to be carried out by Messrs. B. Egger and Co., of Vienna and Budapest.

Yaller Dogs in China.—A correspondent who has just returned from China informs us that while in that country he was compelled to eat "yaller dog." The only effect upon his constitution was, he says, that it made him feel a little flat—as if he had been standing at a window watching sheet lightning playing harmlessly about the heavens. We deeply sympathise with our correspondent.

The New Anglo-American Cable.—The steamer "Britannia," belonging to the Telegraph Maintenance Company, has arrived in Valencia Harbour heavily laden with cable for the purpose of laying the Irish shore end of the new Anglo-American cable from Valencia Island, where the offices of the Anglo-American Cable Company are situated. The new cable will contain 200lb. of copper per mile more than any cable hitherto laid across the Atlantic to the New World.

Electricity v. Gas.—At a recent meeting of the Ulverston Local Board, on the report of the Water and Gas Committee being brought up, it was mentioned that the Lonsdale Iron Company and the Ulverston Paperworks had been offered a reduction of 10 per cent. in the price of their gas, but both firms had now adopted the electric light as the cheapest and most efficient illuminant for their purpose.

The British Association.—As stated in our issue of 4th ult., the British Association will open their sixty-fourth meeting at Oxford on August 8. We have already given the outline of the programme. Authors are now reminded that they should prepare an abstract of their memoirs of a length suitable for insertion in the published *Transactions* of the association to be sent, together with the original memoir, on or before July 11, addressed "General Secretaries, British Association, Burlington House, London, W. For Section ——."

The Lighting of the Bourbon Palace.—The French Chamber of Deputies have under consideration the lighting of the Bourbon Palace, it being proposed to devote a sum of 500,000f., or say £20,000, on machinery for an electric light installation. At present the Chamber pays 122,000f. a year for the lighting. With the expense of the plant once paid, the annual cost for lighting would not be over 72,000f., thereby effecting a saving of 50,000f., or £2,000, which would allow of the initial outlay being recouped in 10 years.

Electric Lighting at Urach.—The Municipality of this Wurtemberg town have decided to introduce the electric light. It is intended to utilise the water power of a saw-mill in the neighbourhood. The streets will be lighted by incandescent lamps, and experiments with such have already been made in the market place. It is also proposed to supply electric power for small industries. As there is no gas company in the place, it is expected that there will be a good demand for light. The Esslingen Machinery Works will carry out the installation.

Imitation.—It is wonderful how when one person has devised any system or apparatus, others subsequently come forward and invent the same thing and call it an improvement. For instance, since Mr. Lineff devised his closed-conduit method of electric traction, plenty of people, especially in the United States, have come forward with similar systems, and now MM. Claret and Wuilleumier according to the *Génie Civil*, have invented a method of electric traction about to be tested in Lyons, and which from the description appears to be the same as the Lineff.

The Paris Underground Electric Railway.—In our last issue we gave particulars as to the progress then made in the promotion of this scheme. The Railway Committee of the Chamber of Deputies have now heard evidence, and have approved of the project by 12 votes to 2. The two opponents are Messrs. Boudenoot and Chavoix, both of whom are engineers, and who hold that the scheme is not practicable. The Railway Committee, though only 12 took part in this first vote, consists of 33 members, and the result arrived at will not prejudice in any way the final decision.

Cable Nomenclature.—The fifth edition of the "Nomenclature of Cables," published on April 25, 1892, by the *Journal Télégraphique*, has now been exhausted. The Bureau International des Administrations Télégraphiques, of Berne, is now preparing a new edition which is expected to be ready for publication in that journal in October next. It is intended in the new edition to sub-

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stitute for the lengths in nautical miles of cables and conductors, lengths in kilometres, so that the figures will be in accord with those issued periodically in that journal concerning telegraphic statistics.

The Queen's Birthday Celebration.—On the occasion of the celebration of the Queen's birthday on Saturday, some novel devices in electric lighting were exhibited in the West-end. At the Queen's birthday party last year the Foreign Office was lighted by electricity. That was an improvement due to the private enterprise of Lord Rosebery. Encouraged by the success that attended the experiment, the Board of Works subsequently authorised, as stated in our last issue, the permanent installation of the light, which on Saturday shone over the assembly which crowded the Foreign Office.

Lighting of Railway Lines.—The *Moniteur Industriel*, in referring to the dropping of various kinds of merchandise from railway goods wagons in France, suggests that for the protection of express trains running along the same lines, the tracks should be lighted by electricity. This is not a bad idea—for France. Here in England we do not drop goods in the manner mentioned; we only drop bad debts and bad acquaintances. At the same time, the lighting of railway tracks could, seriously speaking—or writing, should we say—be easily effected by the use of large electric headlights on the locomotives, a kind of industrial monitor.

Electric Lighting at Gisors (Eure).—The gas company in this French town some time ago declined to establish electric lighting plant, although bound to do so by the terms of their concession. A local merchant then made a proposal to the Municipality. He acquired ground opposite the gasworks and established a central station in the short period of two months. There is a multitubular boiler, a 70-h.p. Weyer and Richemonde steam-engine, and a Gramme dynamo having an output of 300 amperes at 120 volts. Overhead conductors and the two-wire system are employed. There are now about 700 lamps installed.

Electricity at Crone-on-the-Brahe.—It has been decided to erect a central electricity station for the supply of current for lighting and power purposes. Water power is available to the extent of 350 h.p. It is proposed that the station should have a capacity for the supply of 2,000 incandescent lamps of 16 c.p. simultaneously in operation, or their equivalent in arc lamps, and for the supply of current to motors a total of 80 h.p. The question is also being considered of an electric railway of normal gauge, about 6½ miles in length, from Crone to the Maximilianowo railway station, to be supplied with current from the central station.

Self-Contained Vehicles.—As we have previously mentioned, a competition of self-contained vehicles has been promoted by the *Petit Journal* of Paris, and will take place in the latter half of next month. There are 102 entries, but of these only a few in which electromotors are to be employed. These are as follows: An electric phaeton to carry four, by M. Monges, of Paris; M. P. Geoffrey's carriage; a carriage for two, of Count Carli, an Italian deputy; a carriage for six, by M. Soudais, of Fontenay-Sous-Bois, with "a semi-electric motor" (*sic*); and an electric carriage by Mr. Garrard, who is described as an Englishman. Most of the vehicles will be actuated by petroleum motors, this source of energy being the readiest obtainable on the route to be taken.

Construction of Magnetic Apparatus.—A paper has been read by M. S. Wild before the Academy of Science in St. Petersburg on the construction of magnetic instruments. The paper comprised four sections. The first dealt with the results of experiments showing that metallic wire is preferable to silk thread for the suspension of magnets; the second with the degree of accuracy of the readings when instruments are placed in buildings constructed of material containing iron, such as ordinary red brick; in the third part the author described a little magnetometer for the determination of the value of the horizontal component of terrestrial magnetism; and the fourth section dealt with various improvements on the magnetometer made by M. Wild.

Private Telephones.—Our attention has been called to a system of internal telephone installation, adapted, for instance, to large offices, works, and other private buildings, whereby the various departments are enabled to obtain immediate and direct communication with each other, at the same time doing away with the necessity for a central switchboard and attendant. This method is being developed by the Private Wire and Telephone Installation Company, of 110, Cannon-street, E.C., who have already fitted the apparatus with telephones throughout the *Times* offices, and are engaged on a similar contract for the new offices of the *Daily Chronicle*. At the offices of the latter, instruments are being fitted in eight departments. The wiring between the various points is taken from every to every other point, each station being provided with a small plug and keyboard, so that each point can call up any other direct.

Electrically-Welded Continuous Rails.—According to the *Engineering News*, continuous rails, electrically welded, are to be used on the Baden and St. Louis Electric Railway, and the Johnson Company, of Johnstown, Pa., is doing the welding with its special car. In this connection the *Street Railway Gazette* states that the West End Company does not regard the electric welding of rail joints as successful so far as it has been applied in Boston. Trouble has been constantly experienced with the breaking of the joints. The company, however, seems to consider its test of welded joints insufficient to justify any unfavourable conclusions, and within a short time the Johnson Company will make a new experiment. In this case a different style of weld will be tested which, it is believed, will prove far stronger and therefore much more successful. With the heavy rolling-stock owned by the West End the best joints available are urgently needed.

Variable Speed Gear for Electric Traction.—We understand that the Gas Traction Company has secured an exclusive license to use the Beaumont variable power gear for gas and oil traction purposes on tramways and light railways. It is to be hoped that English electric traction interests will not allow this key to successful electric traction to slip into the hands of an enterprising foreign firm. Its value has been recognised by mechanical and electrical engineers, although some electricians still adhere to the idea that the difficulties can be surmounted by electrical rather than by mechanical means. This, as we have before pointed out, is only partly true, for no electrical means reduces the power required to be provided for starting, or the size and weight of the motors required for ascending hills. We illustrated this gear last September, and the necessity for it has been again and again pointed out, and most recently in the paper by Mr. David L. Barnes.

Modification of the Lipmann Electrometer.—Those who have made use of the Lipmann electrometer know that this apparatus works regularly, provided that it is used daily. If the appliance is allowed to rest for a length of time, the capilliary tube becomes choked, and the mercury contained therein becomes idle. M. Limb has just overcome this defect by an ingenious modification of the instrument. The cause of deterioration being entirely

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due to the presence of the mercury in the tube, it is only necessary to remove the mercury from it during experiments. This result is obtained by an arrangement identical to that employed in some barometers. The tube is connected to an indiarubber pipe, terminating in a glass funnel, which is easily movable. At the end of the experiment the mercury is replaced. Another modification, according to *L'Industrie Electrique*, consists in providing the microscope with a projection cone, which allows of readings being taken with the naked eye.

An Electric Log.—Admiral Fleuriais, of the French navy, brought out an electric log which was tried on the "Magicienne" in 1878. It may be described as a small watermill with a wheel consisting of cross-arms tipped with cups like the anemometer of Robinson. There were two sets of four cups mounted on the ends of the same axle, and as they revolved in the water while the ship moved, a contact on the axle interrupted an electric current flowing through a wire between the ship and the log, and sounded a telephone. The note given out by the telephone was a measure of the number of revolutions per minute of the log and the speed of the ship. At high speeds, however, the ear was not quick at recognising the note, and Admiral Fleuriais has substituted for the telephone an electric bell, which is struck every 24 revolutions of the mill wheel or vanes. By timing the interval between two strokes of the bell the speed of the ship is obtained. The apparatus has been tried on board the "Ocean" and other men-of-war, and recently adopted by the Minister of Marine.

Cable Interruptions and Restorations of Lines. The following table is self-explanatory:

	Interrupted.	Restored.
Cable, Brest — St. Pierre, belonging to Anglo Company.....	April 6, 1893.	Not yet.
Cable, Paramaribo — Cayenne	Oct. 25, 1893.	Not yet.
Cable, Bissao—Bolama	Nov. 24, 1893.	Not yet.
Cable, Para — Maranham.....	March 24, 1894.	May 15, 1894.
Cable, Brest — St. Pierre, belonging to Pouyer Q.	March 28, 1894.	Not yet.
Land line, Bagdad—Fao	April 23, 1894.	May 1, 1894.
" " "	May 20, 1894.	May 21, 1894.
Siberian land lines.....	April 24, 1894.	May 2, 1894.
" "	May 9, 1894.	May 10, 1894.
" "	May 11, 1894.	May 14, 1894.
" "	May 19, 1894.	Not yet.
Moulmein — Bankok line	April 30, 1894.	May 2, 1894.
Saigon—Bankok line...	April 28, 1894.	May 2, 1894.
" " " ...	May 15, 1894.	May 20, 1894.
Kotonon — Accra — Lagos	May 21, 1894.	Not yet.

Power Distribution by Electricity, Water, and Gas.—The next ordinary meeting of the Society of Engineers will be held at the Town Hall, Westminster, S.W., on Monday next. A paper will be read on "Power Distribution by Electricity, Water, and Gas," by Mr. Ed. C. de Segundo, of which the following is a synopsis: Definitions of "efficiency"—Efficiency of steam-engine and boiler—Efficiency of gas-engine and generator—Thermal value of town gas—Carnot's function cannot be applied easily to gas-engine performance—Maximum probable temperature attained in gas-engine cylinder—Chief faults in gas-engines of present day—Efficiency of individual portions of plant in electric central generating stations—Efficiency of old plant in practice—Similar considerations relative to hydraulic power stations—Steam-engine not so wasteful a heat machine as usually considered—Initial form of energy available, and final form required as factors in economy of distributing systems—Hydro-electric scheme—Comparison with purely electric distribution—Scheme for gas-engine electric sub-stations for electric lighting of towns—Efficiency of gas burner—Efficiency of electric burner—Others reasons in favour of this scheme—Example of utilisation of existing hydraulic power supply for private electric light installations—Conclusion.

Alternate-Current Electrolysis.—A paper on this subject is given in the *Proceedings* of the Royal Society by Dr. J. Hopkinson and Messrs. E. Wilson and F. Lydall. The paper contains the results of a number of experiments, the object of which was to determine (1) the dissipation of energy due to electrolytic hysteresis, and (2) the quantity of an ion per square centimetre of an electrode necessary to change the properties of the electrode to that of the ion during alternate-current electrolysis. The experiments were carried out by passing an alternate current through an ordinary non-inductive resistance and through an electrolyte, and then measuring the differences of potential at the extremities of these two resistances at different phases of the current. Curves of current and potential differences with different frequency are given, as well as curves showing the dissipation of energy per cycle. As a result of the experiments, it was found that with platinum electrodes of 150 square centimetres area, the ion being hydrogen, the maximum E.M.F. due to polarisation was reached when one-tenth of coulomb had passed through the cell—that is, when 0·00001 gramme of hydrogen had been liberated. It hence appears that 0·00000007 gramme of hydrogen is sufficient to polarise one square centimetre of platinum. Assuming the density of the hydrogen to be comparable with that of liquids, the thickness of the film of hydrogen necessary is of the same order as this number—0·00000007cm.—a number comparable with the distance between the molecules.

Lightning Stroke. — Ball lightning, the *fulmen globulare* of the older meteorologists, is the most dangerous and destructive of the forms which lightning is known to assume. Fortunately, however, it is the rarest. A narrow escape from death by its stroke, the *Lancet* says, occurred lately in the person of a distinguished surgeon of the Belgian school, Dr. L. Dandois, Professor of Surgery in the University of Louvain, who had gone to the neighbouring town of Linden to visit a patient, and on his return, having alighted from the train to continue his homeward journey by road, was overtaken by a heavy thunderstorm. The sky became as dark as at midnight, so as to make it difficult for him to avoid the telegraph poles standing at intervals along his path. In a few minutes a fireball, as he described it, descended on him, its stroke hurling him off the road, across the ditch that ran parallel to it, and landing him in the adjacent field. He was holding a large umbrella at the time, holding it with both hands by the wooden stick, which was of uncommon thickness. On coming to himself after the shock he found the umbrella cover completely burnt off its steel framework, the steel itself being twisted into every sort of shape. The wooden handle had no doubt saved his life—had it been of metal Dr. Dandois is convinced that he must have been killed instantaneously. As it was, fully 10 minutes elapsed before he recovered the use of his arms and legs, benumbed as they were with the shock. Ultimately he was able to resume his walk homeward.

Volk's Electric Railway.—A four minutes' service is now maintained on this electric railway, four cars being in operation. There are two new saloon cars; and a 20-h.p. Tangyes engine and a 26-unit Kapp dynamo, made by Messrs. Johnson and Phillips, have been put down at

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the generating station. By altering the switch the E.M.F. can be made to rise with the current, so that the E.M.F. on the line does not drop when more cars are running, as it would otherwise do, owing to the extra loss in the leads. We understand that over 8,000 people travelled on the railway on Whit Monday. The cars are worked two running and two loading all the time, thus increasing the capacity 60 per cent. without putting any more strain on the machinery. The old generating plant has been retained as a stand-by, or as a reserve. In the case of the Brighton and Rottingdean Railway, we are informed that the whole of the material has been delivered, and the rocks, etc., are now being levelled preparatory to laying the rails. The rails are 53½lb. to the yard, and are made of specially rolled steel. The track will consist of four rails, owing to the great width and capacity of resisting the force of the sea. The cars themselves will be constructed like the deck of a saloon, after the pattern of a steamship, affording room for passengers to walk about. Each car will carry about 150 persons. The piles for the jetty are all driven at the Brighton end. All the iron and steel work is nearly ready for delivery for the jetties at both ends. It is expected that the railway will be in working order for next summer's season. All the detailed plans have been passed by the Board of Trade.

Electric Phenomena During Thunderstorms.—Mr. C. S. Du Riche Preller, writing from Baden to the *Standard* of yesterday's date, says: "Some exciting and horribly beautiful, but also very dangerous, electric phenomena were observed in the picturesque canton of St. Gall, on the evening of the 25th inst., during a thunderstorm of extraordinary violence, accompanied by a deluge of rain. The large 'village' of Gossau, about seven miles from the town of St. Gall, derives its electric supply for lighting and motive power for industrial purposes from a hydro-electrical central station, situated at a distance of eight miles, by a high-tension transmission, with transformer stations in the village. The thunderstorm, accompanied by violent lightning discharges, passed over the place at 5 p.m., and then, driven back by a change of wind, returned, and lasted for several hours. Soon after 5 p.m. all the electric lights went out spontaneously, but the place was illuminated by violent sparks and flashes, which were emitted by the overhead wire system, and ran along the conductors. These phenomena reached their height at the principal transformer station, close to an hotel; for here the high-pressure current escaped from the conductors to earth—viz., the ground saturated with rain—the effect being a succession of flashes or continuous blaze, which so endangered the building that the fire brigade had to be called out to protect it. These phenomena continued for several hours, till the electric supply was cut off at the central station, a special messenger on horseback having been despatched thither, for, wonderful to relate, the installation was as yet without telephonic communication. The lightning struck several houses in the village, though without doing harm; but a young man of powerful build, and of local position and great promise—for he was to have been elected mayor on the very next day—inadvertently touched one of the electric cables, and was instantly killed. The inhabitants of the place might have been spared the terror of these phenomena, and probably no human life would have been lost, if the electric supply had been cut off during the altogether exceptional thunderstorm, as should always be done—and in the United States is done on some electric tramways—in districts visited by violent atmospheric discharges, and where overhead wires are used. Only last summer I witnessed a similar occurrence on the Mont Salève electric railway, near Geneva, where the lightning struck the feed-conductor of the line, and thence found its way along the transmission cables to the central station, fully two miles distant, where it passed through the lightning arrester and burnt out one of the huge 1,000-h.p. dynamos. In this case, too, the lightning discharge was only the indirect cause, the direct cause being that the dynamo was running at the time—viz., that the current followed the discharge through the not quite perfect lightning arrester and 'short-circuited' the dynamo.

The Budapest Electric Tramways.—Some little time ago Alderman Ward, a member of the Leeds County Council, being over in Vienna on business, paid a visit to Budapest, with a view to seeing the system of electric tramways there in use, and he has favoured a Leeds paper with an account of what he saw. The Budapest electric tramway was first begun some six or seven years ago by Messrs. Siemens and Halske, and when it had been completed, so far as the present lines are concerned, they floated it as a company, with a capital of 4,000,000fl., which in English money is a little over £330,000. The company in the first year of its existence paid a dividend of 7 per cent. on its capital, and last year it paid 8 per cent., and the shares on the market to-day stand at 225fl. for every 100fl. invested. The power station is centrally situated, and from this point all the lines are worked. The total capacity at the company's disposal represents 1,750 h.p., which means that they possess a duplicate service of dynamos and engines in the event of a breakdown. On ordinary weekdays about 600 h.p. is required to work the traffic, but on Sundays—the continental holiday-making day—from 800 h.p. to 900 h.p. is required. The fare charged is six kreutzers for one length; if a change is made, taking an additional line, the charge is eight kreutzers; but if a double change is made, then 10 kreutzers is the fare. This means that for about 2d. English money a passenger may travel six to seven miles. The total length of the lines laid down on the conduit system is about 30 kilometres, or 18½ English miles. There is also a short distance of tramway on the overhead system, but this will be reconstructed on the conduit system as soon as convenient. At first the company experienced some little difficulty in working the lines, occasioned by mischievous people interrupting the electric current by putting a piece of metal down the conduit, but this form of amusement did not last long, and they have experienced no trouble of late. Slight interruption has also been met with from drifting snow, but it has never been of any serious duration, from half to three-quarters of an hour always sufficing to clear away the obstruction. In the low-lying portions of the city heavy rains have also occasioned slight difficulty, owing to the sewers not having sufficient capacity to take off the surface water which has flooded back into the conduit. But, with these slight drawbacks, the system works as smoothly as can be wished. Each carriage is constructed to carry 32 persons, but as no by-laws exist against overcrowding, standing room is permitted, and so on occasions cars may be seen with from 60 to 70 people in them. Each car, including the motor, weighs from 4½ to 5 tons, and cost about £500. The system is most popular in Budapest, and last year the company carried no less than 12½ million passengers, which practically means that, taking an average, each individual inhabitant used the cars 21 times in the course of the year. This year, however, the company expect to overtop these figures by 2,000,000. The cost of construction per kilometre, including the power station, workshops, waiting-rooms, cars, etc., is stated to be 95,000fl., or say about £13,350 per English mile.

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AUTOMATIC ELECTRIC SIGNALS.

The only instance, we think, of automatic electric signalling at present used in this country is the method invented by Mr. I. A. Timmis, and employed on the Liverpool Overhead Railway. For many reasons, the Board of Trade—as the supervising department of all railway operation systems—has rightly set itself against the adoption of automatic working until at least an equal if not greater degree of safety is obtained with absolute certainty by its use, as compared with the employment of human motive power in the shape of signalmen. Judging, however, by the results obtained on the Liverpool line, and by the experience of American railroads—where automatic block working is in quite considerable service—the time has now come when the element of human fallibility in signalmen is likely to average out somewhat greater than the possibility of failure in the electric or other automatic mechanism, and seeing that a failure, whenever it occurs, may be caused always to tend towards safety with the latter system rather than towards danger as it often does with the former, there is the more reason for adopting any reliable automatic appliance, especially in view of its saving in cost of operation.

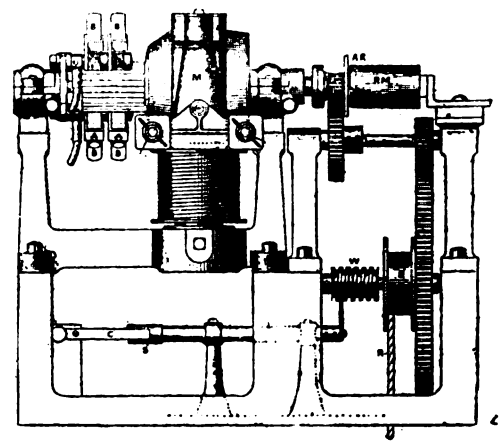
Of course, the ultimate action of an electric signal is due to the use of a magnetising force, in whatever way this be ultimately applied. On the Liverpool line, for instance, Mr. Timmis uses the pull of a specially-designed magnet itself to actuate the signal lever and clear the line, or the reverse. For many reasons, such a method has strong recommendations; its directness, reliability, and simple design are all points of great importance in assessing its standard of merit, and probably will continue to give it a leading position amongst such appliances. There are, however, other devices and methods of application possible for achieving the same end, and we illustrate in the annexed engraving an arrangement which has had considerable service on American railways, with, it is stated, satisfactory results.

One of these appliances consists of a small electric motor, which is operated by a battery of ten or a dozen Edison-Lalande cells, the circuit being made or broken in the usual way by the trains themselves as they pass over treadles or contacts on the line. When the current thus traverses the motor armature, the latter rotates, and through some gear wheels actuates a drum. Upon this is wound up a short length of fine wire rope connected to a rod or lever, which throws the semaphore arm down—the reverse action—*i.e.*, unwinding the wire rope—allowing a counterweight to pull the arm into the danger position again.

This apparatus is designed by Mr. J. W. Lattig, of the Lehigh Valley Railroad, and manufactured by the National Switch and Signal Company. In the method of installation recommended by the makers, both a line battery and a local battery working the signal are employed. These are normally at rest, the circuits being open; the signals stand in the "danger" position, being held there by the counterweights. When a train approaches a point where it is desirable to obtain the signal indication (and this point may be placed at any convenient distance before the signal is reached), an extension of the line or track circuit, either by overhead wire or cable, is closed by any of the usual contact-making devices, either electrical or mechanical. Provided the section ahead is unoccupied, the track circuit being thus closed, a current is transmitted through the rails from the extreme end of the section in advance and energises a relay controlling the local battery circuit, which being thus closed, the local battery current at once passes through the motor, setting it in motion, as already described.

After the motor has actuated the signal, its current, by an ingenious arrangement of worm gear, is then shunted to a releasing magnet. This grasps a circular armature, upon the spindle of which slides the motor pinion, and this being firmly held, prevents unwinding of the rope so long as the track circuit energising the relay remains unbroken. When, however, this circuit is interrupted, or the current is short circuited by the train entering the section so as to demagnetise the relay, the releasing magnet is de-energised, and the motor circuit broken at the same time. This allows the semaphore arm to return to its normal (danger) position, the gearing and motor revolving backward as the rope unwinds from the drum. Everything being now in normal position, all circuits open and the semaphore at danger, no further movement takes place until the approach of the next train, when, if the preceding train has not cleared the section which the signal controls, no "line clear" signal is obtained, although the train may have closed the track circuit at the point where the operation of the signal is effected.

In the illustration showing the elevation of the motor mechanism, M is the motor, R M the releasing magnet, with the circular armature, A L, attached to the sliding pinion, feathered on the shaft of the motor so that a free movement of the armature, A R, is permitted. When the current is shunted to the releasing magnet, R M, the pinion is held from rotating by the armature, A R, being firmly attracted to the magnet, thus preventing a backward movement of the gearing while the signal is being held in the clear position.



The pinion operates, through other gear wheels, the drum, D, upon which the rope, R, is wound; at the same time the worm gear, W, by means of an arm and rod to which it is attached, withdraws the contact, S, from between the springs, C C, thus opening the motor circuit and at the same time shunting the main battery current to the releasing magnet, R M, which, as above stated, acts like a pawl to hold the gearing motionless while the semaphore shows "line clear." The action of the batteries thus only continues during the interval of time elapsing from the moment when the train closes the track circuit until the signal is passed and the relay current is short-circuited by the entrance of the train upon the section. The signal may either be located at the entrance of the section or it may be placed a certain distance within the preceding section, so that the return of the signal to the danger position need not take place until the train has passed a certain prescribed distance beyond the signal-post, which, of course, so far as the engine-driver is concerned, marks the limit of the block section.

The maximum speed of operating the signal is two or three seconds; then the motor circuit is shunted, and but a fraction of the current used for the holding magnet until the train reaches the signal.

LONDON UNDERGROUND RAILWAYS.

Apparently the Waterloo and City line is at present the only one of the many projected and authorised Greathead tunnel electric railways which will achieve an early completion. The Central London line, like Scotland, "stands where she did." An extension of time limit for its completion has been obtained from Parliament; all the necessary arrangements have been entered into with local authorities and other interests along the line of route; the promoters are amply satisfied with the powers of electric working to give them, the public, and the shareholders complete satisfaction in every respect; and sufficient capital for construction and equipment is at hand and obtainable when necessary. No decisive step, however, has been

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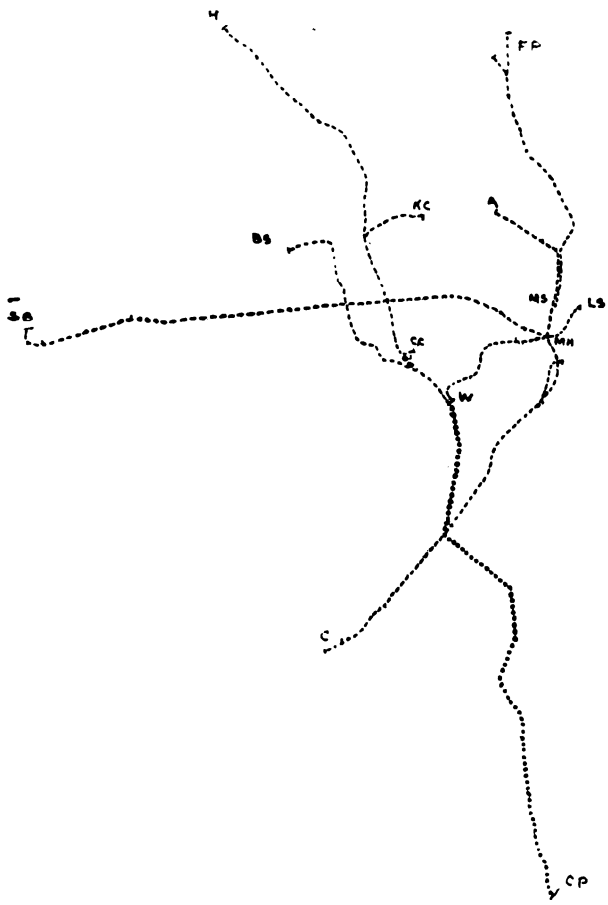
taken, and no contracts as yet entered into, the promoters wishing to choose a moment for developing the project that shall be the most expedient possible. Somewhat similar conditions govern also the new works of the City and South London line, though doubtless these will at once be undertaken as soon as the necessary financial arrangements can be made. The ill-fated Hampstead and Charing Cross line will again come before the public at a later date in a reorganised and greatly improved form, and it is much to be hoped that more substantial support will then be accorded to the project. Meantime, it may not be out of place to put before the promoters of this line the question of so far increasing its scope, and consequent value, as to carry it beyond the River Thames, through the South of London, to the Crystal Palace district. At the present moment it actually takes an unfortunate traveller across London the same time to pass, say, from Brixton or Sydenham to Hampstead, as would suffice for a railway journey to Leicester or Bristol from the Metropolis. The Crystal Palace has by no means an overplus of ways by which it may be reached conveniently even from the City or West-end, apart from the North of London, and although additional parliamentary powers would



of course be required for such an extension as that now proposed, the suggestion is well worth being considered in all its bearings. The other two lines authorised—viz., the Baker-street to Waterloo, and the Finsbury Park to Moorgate-street—are still in the chrysalid state, but we understand that they will shortly emerge from this into a more active condition. The matter of a junction between the former and the proposed extension of the Hampstead line southwards from Charing Cross, would probably also be worth consideration. Indeed, the new underground system of London, on the Greathead system and worked electrically, appears to be already gradually tending towards the form of a double centre—the Mansion House and Waterloo respectively—from which radiate arms and branches in all directions. This is shown by the annexed diagram, which represents the railways thus mentioned: the dotted lines give the routes followed, the termini being respectively Finsbury Park (F. P.,) The Angel (A.), Moorgate-street (M. S.), Liverpool-street (L. S.), Mansion House (M. H.), Waterloo (W.), Charing Cross (C. C.), King's Cross (K. C.), Hampstead (H.), Baker-street (B. S.), Shepherd's Bush (S. B.), and Stockwell (S.). The suggested extension to the Crystal Palace (C. P.) is represented by the line of small circles; this shows very clearly the comparative ease with which the Hampstead line might be carried on southwards across the river to Sydenham, either through districts not very well served at present—as given on the diagram—or else passing through the Clapham terminus of the South London line, and then onwards to the Crystal Palace. This is a longer route, but would give a better arrangement of lines, unless connection is made, say, at The Elephant and Castle, between the lines where they cross in the diagram.

ON THE SUBDIVISION AND DISTRIBUTION OF ARTIFICIAL SOURCES OF ILLUMINATION.*

BY PROF. WILLIAM A. ANTHONY.

It is a well-recognised principle that to illuminate evenly a given area by means of an artificial source, it is necessary that this source should consist of numerous small sources distributed over the area. In carrying out this principle it is usual to divide the area to be lighted into squares, and place a lamp in the centre of each square, as shown in Fig. 1, where each lamp is represented by the sign ×. In order to study the distribution of light by this arrangement of lamps, I have computed the illumination at the central point of the

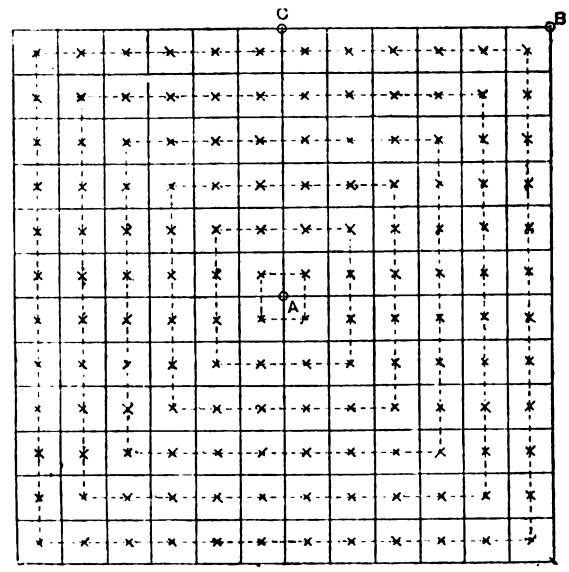


FIG. 1.

figure due to the lamps situated upon the boundaries of each of the squares represented by the dotted lines, the illumination produced by the lamps on the smallest square being taken as unity. The following table gives the values up to the twelfth square, twice the number represented in Fig. 1, and corresponding, therefore, to an installation in which four times as many lamps are used:

I.	II.	III.	IV.	V.
1	1·000	1·000	4	4
2	·511	1·511	12	16
3	·312	1·823	20	36
4	·223	2·046	28	64
5	·174	2·220	36	100
6	·143	2·363	44	144
7	·121	2·484	52	196
8	·104	2·588	60	256
9	·092	2·680	68	324
10	·083	2·763	76	400
11	·075	2·838	84	484
12	·067	2·905	92	576

Column I. gives the designating number of each square counting outward from the central point. Column II. gives the illumination at the centre due to the lamps located on each boundary. Column III. gives the total illumination at

* A paper read at the eleventh general meeting of the American Institute of Electrical Engineers, Philadelphia, May 15, 1894.

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the centre due to the lamps included within and upon each boundary. Column IV. gives the number of lamps situated upon each boundary. Column V. gives the total number of lamps.

It is seen from the table that the twelfth series, which consists of 92 lamps, gives at the centre less than 7 per cent. as much light as the first series of four lamps, and contributes only about 2½ per cent. to the total illumination at the centre. This arrangement of the lamps does not give an even distribution of light over the entire area, as will be evident from a consideration of the illumination upon the outside boundaries of the space. It is evident that the point B at the corner of Fig. 1 receives one-fourth as much light as it would do if it were the centre of an area four times as large, and lighted by four times as many, or 576 lights. But the illumination at the centre of such an area as seen by the table is 2·905. The illumination at B is, therefore, 2·905 ÷ 4 or ·726, while the illumination at A from the sixth line of the table is 2·363. The illumination at B is then less than one-third that at A. At C the illumination is evidently but little more than half that at A. Points located between the centre and outside would be illuminated to an intermediate degree, but after leaving the outer boundary the illumination would rapidly approach that at the centre of the figure. I am considering always points of least illumination in any region—that is, points situated as far as possible from any lamp. It is evident, therefore, that to obtain a uniform distribution of light, the lamps must be concentrated towards the outer boundary of the space instead of being placed at equal distances throughout, as in the figure.

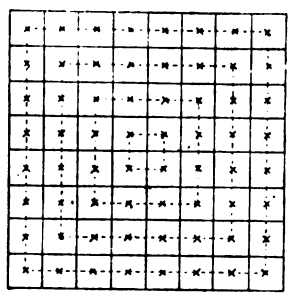

Fig. 2.

But the most interesting question connected with this matter is: what is the effect upon the uniformity of the illumination of grouping the lamps in clusters or using larger lamps at fewer points? It is evident that whatever the candle-power of the lamps or their distances apart in a distribution like that represented in Fig. 1, the relations represented in the table will remain unchanged. It is evident also that the illumination of the central point will be proportional to the intensity of the individual sources (if lamps are placed in clusters, each cluster is to be considered as a source) and inversely to the square of the distance between the sources.

This illumination, is, therefore, given by the formula

$$K \frac{s}{d^2} C,$$

where K is a constant depending on the units employed, s the intensity of the individual sources, d the common distance between them, and C the quantity in Column III. of the table corresponding to the number of sources as found in Column V.

Compare the illumination at the centre of an area lighted by 576 lamps with that at the centre of the same area lighted by the same lamps arranged in 144 clusters of four lamps each. If s and d represent the intensity and distance in the first case, $4s$ and $2d$ will represent the corresponding quantities in the second case. C in the first case is 2·905 corresponding to 576 sources. In the second case, for 144 sources C is 2·363. The relation sought is, therefore,

$$\frac{K \frac{4s}{4d^2} 2{\cdot}363}{K \frac{s}{d^2} 2{\cdot}905} = {\cdot}813$$

The light at the central point with the fewer sources is only 81 per cent. that obtained under the first arrangement. Other points of minimum illumination will suffer in like manner. On the other hand, points near the clusters of lamps will be much more strongly illuminated than corresponding points near the single lamps of the first arrangement.

If it be required that the illumination at no point shall be less in the second case than in the first, it will be necessary to increase the intensity of the sources nearly 25 per cent., or make the cluster consist of five instead of four lamps.

Again, suppose an area lighted by 64 16-c.p. lamps distributed as in Fig. 2. It is required to substitute 16 lamps of larger candle-power distributed as in Fig. 3, and fulfilling the condition that the minimum illumination shall be no less in the latter case. If x be the candle-power of the larger lamps, we have:

$$\frac{x}{4d^2} \times 1{\cdot}511 = \frac{16}{d^2} \times 2{\cdot}046,$$

$$x = 64 \times \frac{2{\cdot}046}{1{\cdot}511} = 86{\cdot}7.$$

From which it appears that the total candle-power must be increased 35½ per cent. If the 16-c.p. lamps consumed 3·5 watts per candle, the larger lamps to compete with them should consume less than 2·6 watts per candle.

It will be noted from the two examples given, that the loss from reducing the number of sources in a given ratio is less when the number is large. In other words, large lamps, or clusters of lamps, can be more economically used for large than for small areas.

An inspection of the table will show, that while a given area may be lighted satisfactorily by 16 clusters of four lamps each, an area one-fourth as large, lighted by four

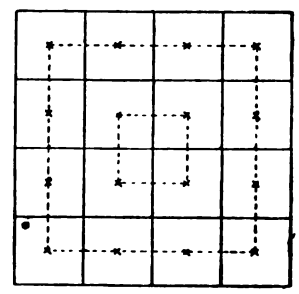

Fig. 3.

clusters at the same distance apart, would not be as well lighted with six lamps to the cluster. It will be seen also that the larger the area, the further apart may lamps of the same candle-power be placed. For example, a room 40ft. square with 16 lamps 10ft. apart, is fully as well lighted as a room 16ft. square with four lamps 8ft. apart.

Let us compare arc and incandescent lights on the same basis, that the minimum illumination shall be the same under both systems. First, I must say that the efficiency of arc lights has been greatly overrated. Instead of being 10 times it is rarely three times, and often only one and a half times that of an incandescent lamp.* This is for the naked arc. For indoor illumination, ground or opal globes are nearly always used, and these cut off fully half the light.† This leaves the efficiency at the most 1·5 times that of the incandescent lamp. The power required for a 16-candle incandescent lamp is 50 watts, and for a full arc lamp 450 watts. The arc lamp must, therefore, replace nine incandescents. Assuming that the lamps are distributed as described in this paper, the table shows that if four arcs take the place of 36 incandescents, their efficiency as compared with the incandescents must be 1·823, and with a relative efficiency of only 1·5, the arc lamps would not light the space as well as the incandescents. If 16 arcs take the place of 144 incandescents, the ratio of the efficiencies required is 1·56, and arcs at 1·5 are still not equal to the incandescents. If 64 arcs take the place of 576 incandescents, the ratio of the efficiencies becomes 1·42, and arcs at 1·5 would be an improvement on the incandescents. It comes then to this, that unless the area to be lighted is so large as to require about 500 incandescent lamps distributed uniformly over it, the use of full

* See "Efficiency of Artificial Methods of Illumination." Dr. Nichols: *Transactions*, vol. vi., p. 171.

† "Loss of Light from Use of Globes with Arc Lamps." George D. Shepardson: *Electrical World*, vol. xxiii., p. 287.

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TABLE OF CENTRAL ELECTRIC LIGHT STATIONS.

No.	Town.	Population.	Date of opening.	System of distribution.
1	Aix-la-Chapelle.....	103,500	Jan., 1893	Direct on three-wire system, with batteries.
2	Altona	143,249	Feb., 1892	Ditto ditto.
3	Barmen	125,000	Dec., 1888	Ditto ditto.
4	Bremen	135,000	Aug., 1893	Direct on three-wire system, with sub-battery stations.
5	Breslau	355,186	June, 1891... .	Direct on three-wire system, with batteries.
6	Cassel..	75,000	July, 1891	Two sub-battery stations, the batteries being charged by rectified alternating current.
7	Darmstadt	56,400	Aug., 1888.....	Direct on three-wire system, with accumulators.
8	Dessau	40,000	Oct., 1886	Direct on two- ditto.
9	Düsseldorf.....	155,411	Sept., 1891 ...	Direct on two-wire system to sub-stations, where three-wire distribution commences.
10	Elberfeld	132,000	Nov., 1887.....	Direct on the three-wire system.
11	Gera	40,000	Jan., 1892.....	Ditto ditto with batteries.
12	Greifenhagen	7,000	June, 1892.....	Direct on the two-wire system, ditto.
13	Gummersbach	10,000	April, 1890 ..	Direct on the two-wire system, with battery sub-stations.
14	Hagen(Westphalia)	37,000	Aug., 1890.. ..	Ditto ditto ditto.
15	Hamburg	650,000	Dec., 1888	Ditto ditto, with accumulators.
16	Hanover..... ..	188,000	March, 1891....	Ditto three-wire system, ditto.
17	Cologne	298,732	Oct., 1891	Single-phase alternating, with transformers and no secondary network.
18	Copenhagen	326,000	March, 1892....	Direct on the three-wire system, with batteries.
19	Lübeck	70,000	Nov., 1887.....	Ditto ditto ditto.
20	Mulhouse	76,968	March, 1888....	Ditto ditto ditto.
21	Stettin	120,000	Oct., 1889	Ditto ditto ditto, and a battery sub-station.

arc lamps requiring the same power will leave some parts of the area less brilliantly lighted.

If we could make small arc lamps of the same efficiency as the full arc—by full arc I mean the so-called 2,000-candle lamp consuming about 450 watts—we could improve somewhat upon the result as obtained above. But the fact that the mechanism of a small arc lamp costs just as much as that of a large one, and that each small arc will require as much care and attention as a large one, would place a limit upon the subdivision of the arc even if the efficiency could be maintained. And here I wish to enter a protest against the assumption that I often find in discussions on this subject, that the so-called 1,200-c.p. and 2,000-c.p. arc lamps are 1,200 and 2,000-candle lamps. There is no 450-watt arc lamp in use that will measure 2,000 candles in the direction of greatest intensity, and compared with other artificial sources for general illumination that is measured as other sources are measured, there is no 450-watt lamp that will give, when surrounded by a plain glass globe, 500 candles.

In a linear distribution, as in street-lighting, the arc is at a still greater disadvantage. Remembering that nine 16-candle incandescent lamps can be run with the power required for one 450-watt arc, it is seen that the arcs must be nine times as far apart as incandescents consuming the same power, and to give the same minimum illumination must be 81 times as intense, or about 1,300 c.p. But in no arc lamp as used for street-lighting do the rays proceediug toward the most distant points to be illuminated reach more than one-fourth this intensity. In my way of thinking, the location of arc lamps at intervals of 1,000ft. to 1,600ft., as they are often seen in pretentious country villages and suburban places, is an entire waste of money. A little spot 50ft. to 100ft. in diameter under each lamp is brilliantly lighted, while the more distant points are in darkness all the more profound from the loss of sensitiveness of the eye when in the strong light. Incandescent lamps at intervals of 100ft. to 200ft., which could be run by the same power, would give a far better illumination.

Of course, in deciding between the use of arc and incandescent lamps in any special case, there are other questions to be considered besides that of the power required to operate. Practical questions of installation may outweigh all others. The consideration of these is foreign to this paper. The question I have considered is purely one of efficiency, and in treating that question I have assumed that every part of a space to be lighted needs the same amount of light. I have omitted from the consideration all effects of reflection from ceilings, walls, or reflectors purposely provided, as these are too various, and depend too much upon the conditions in each special case to be introduced into a general discusion. My main object has been to point out to just what extent the general illumination of a space is effected, other things being equal, by the use of large in the place of small sources using in the aggregate the same power, and I trust the figures and illustrations I have given may be found useful in considering the special cases that may arise.

WORKING RESULTS OF SOME CONTINENTAL ELECTRIC LIGHT STATIONS.

A lengthy statistical report concerning the working results of some continental electricity works during the year 1892-93 has been prepared at the request of the Statistical Commission of the Free Union of Representatives of Electricity Works (Freie Vereinigung der Vertreter von Elektricitätswerken). This report, which has been compiled by Dr. O. Gusinde, of Hanover, in conjunction with the editorial staff of the *Elektrotechnische Zeitschrift*, is printed in the latter journal in its issue of May 24. Although the information can hardly be regarded as up to date, yet it is as recent as it is possible to obtain, and a brief summary of the report will doubtless prove interesting.

GENERAL WORKING RESULTS.

No.	Energy produced in hectowatt-hours.			Average demand for power in percentage of the normal output.
	Whole year.	Maximum in 24 hours. (Date.)	Minimum in 24 hours. (Date.)	
1	—	—	—	—
2	2,003,572	22,510 (16/12/92)	692 (7/9/92)	86·5 of the steam-power; 83·4 of the dynamo.
3	1,449,964	10,157 (21/12/92)	469 (12/6/92)	—
4	—	—	—	—
5	4,533,421	34,522 (19/12/92)	2,631 (3/7/92)	100
6	1,794,920	12,654 (21/12/92)	263 (19/7/92)	80·8 and 56·8
7	1,945,599	14,075 (17/12/92)	625 (3/7/92)	—
8	591,348	—	—	100
9	4,841,114	30,019 (21/12/92)	4,976 (22/6/92)	95·6
10	3,410,000	24,847 (21/12/92)	2,095 (26/6/92)	—
11	777,550	5,528 (21/12/92)	370 (14/7/92)	50
12	207,975	—	—	83
13	—	—	—	100
14	—	2,770 (24/12/92)	—	100
15	5,428,802	37,553 (21/12/92)	4,300 (3/7/92)	70
16	4,525,200	32,278 (22/12/92)	3,965 (10/7/92)	80·87 and 71
17	—	—	—	—
18	4,176,118	31,578 (17/12/92)	—	large 70 small 80
19	—	—	—	—
20	1,842,270	11,104 (21/12/92)	1,978 (7/6/92)	81
21	3,148,700	22,600 (17/12/92)	1,560 (10/7/92)	68

It is pointed out that many particulars are given in the annual reports of the electricity works, but that very little

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information is published in them as to the experience gained in working details. This fact led to the bringing together once a year of the engineers of the electricity works, so that a verbal expression of opinion on the subject could be ascertained at the gatherings of the Free Union. The first meeting of the Free Union took place in Berlin in July, 1892, and the second in Dresden in June, 1893, whilst the third will be held in Leipsig on the 5th and 6th inst.

TABLE OF ACCUMULATORS.

No.	Percentage of annual efficiency.		Ampere-hours given in percentage of total output.	Daily discharge in percentage of normal performance.		
	Ampere-hours.	Watt-hours.		Largest.	Smallest.	Average.
1	—	—	—	—	—	—
2	98	79·8	68 6	—	—	—
3	95·2	71·5	33 8	82·8	20·7	46·6
4	—	—	—	—	—	—
5	92·1	—	32·8	133·7	20 1	56
6	88 5	72 9	74·7	131	23	67
7	92	—	15	100	33·7	63·5
8	—	82·1	51	160	15	43·8
9	91·3	77 5	61·9	I 117 II 78 III 107	I 14 II 3·4 III 47	54·3
10	—	—	—	—	—	—
11	74·7	63·3	49·4	114·5	20·6	63·8
12	—	—	—	—	—	—
13	92	79·3	—	—	—	—
14	90·5	78·2	—	—	—	—
15	95	80	30	100	85	80
16	96·6	79·5	41	109	53	75
17	Alternating current	—	—	—	—	—
18	92	74	33	136	13	75
19	—	—	—	—	—	—
20	82·3	76·3	50·3	111·5	11·9	57·1
21	—	—	—	—	—	—

It was decided at the Berlin gathering that an interchange of yearly reports should be carried out, and a commission—consisting of Mr. Döpke, of Cassel; Dr. Gusinde, of Hanover; and Mr. Joly, of Cologne—was appointed to deal with the matter, and to issue a circular asking for answers to various questions. The latest time for sending in replies was August 15, 1893, and to Dr. Gusinde, assisted by the staff mentioned, was allotted the duty of putting the statistics into proper order. The report has now been published. The figures, which only refer to those electricity works associated with the Free Union, are as complete as it was possible to make them. Annexed are some of the most important tabular statements.

THE EFFICIENCY OF ALTERNATING-CURRENT TRANSFORMERS.

THE MORDEY, SCHUCKERT, AND OERLIKON TYPES.

In connection with the late electrical exhibition at Frankfort-on-the-Maine, a committee was appointed under the presidency of Dr. H. F. Weber, of Zürich, on the subject of testing alternate-current transformers, and the official report has now been published.

The following alternate current transformers were given to the committee to test: two Mordey transformers of from 3,000 to 6,000 watts from Messrs. Kremenezky, Mayer, and Co., of Vienna; a 10,000-watt transformer of Messrs. Schuckert and Co., of Nuremberg; and an Oerlikon transformer of 7,500 watts. In order to make the tests as complete as possible, there were measured the primary current strength, the primary pressure, the energy conducted to the primary winding in a unit of time, the resistance of the primary coils, the secondary current strength, the secondary pressure, and by direct measurements the energy leaving the secondary winding in a unit of time, and the resistance of the secondary coils. The measurements of the current strength were made with Thomson balancing instruments and Siemens electrodynamometers; the pressure was measured with Cardew voltmeters; and the primary and secondary energy by means of Ganz wattmeters. The measurements were carried out by Dr. Behn, of Eschenburg, Dr. Kopp, Mr. Nizzola, Dr. Sahulka, Mr. Schmoller, Dr. H. F. Weber, Dr. G. von Wiss, Dr. Dietrich, and Dr. C. L. Weber. Special tests were made as to the accuracy of the measuring instruments.

As the source of current for the tests of the transformers, a Mordey alternating-current machine, supplied by Messrs. Kremenezky, Mayer, and Co., was employed. This machine had a normal output of 25,000 watts, a pressure of 2,000 volts, ran at 850 revolutions per minute, and had a periodicity of 100 per second. Each transformer was tested at different loads in as complete a manner as possible. For the load there was used a system of 300 16-c.p. 100-volt incandescent lamps. The lamps could either be switched in and out in simple parallel in 30 groups of 10, or two in series in 15 groups of 20 lamps each, in the secondary circuit of the transformer.

The speed of the Mordey alternator was kept as far as possible constant during the loads in a series of tests, and the exciting current was so regulated that the secondary tension had almost the same value.

Besides these series of tests each of the four transformers was submitted to a series of experiments, in which there was inserted before the primary winding a resistance, as far as possible free from self-induction, of twice the size of the resistance of the primary winding in order to change and notice the length of the difference of phase of the primary tension and of the primary current strength under small loads.

The two types of Mordey transformers tested were calculated respectively for:

3,000 watts normal output; 2,000 volts primary pressure; 100 volts secondary pressure; number of periods 100.

6,000 watts normal output; 2,000 volts primary pressure; 100 volts secondary pressure; number of periods 100.

These transformers could be tested under their normal conditions, as the alternate-current dynamo feeding the converters served for the production of the primary current.

The Oerlikon transformer was of 7,500 watts output; 2,000 volts primary pressure; 100 volts secondary pressure; number of periods 50. The normal number of periods, however, could not be obtained, as only an alternate-current dynamo with a periodicity of 100 was available.

The Schuckert transformer had a normal output of 10,000 watts, a primary pressure of 2,500 volts, a secondary pressure of 139 volts, and a periodicity of 50.

By applying their normal periodicities as numbers of the change of the primary in relation to the secondary pressure at a constantly maintained secondary in relation to primary pressure between zero and normal load, the values of the four transformers were:

Mordey	3,000-watt	transformer	2·4	Percentages of the outgoing pressure at zero load.
„	6,000 „	„	2·5	
Oerlikon	7,500 „	„	3·0	
Schuckert	10,000 „	„	3·0	

It was found that the loss of energy through heating of the primary and secondary coils at full load was between 2·3 to 2·5 per cent. in the case of the Mordey transformer, 2·36 per cent. with the Schuckert converter, and 1·75 per cent. in the case of the Oerlikon transformer. The amount of loss of energy in the iron was shown by the results to be with both types of Mordey transformers and the Schuckert converter to be independent of the load. The reverse was the case with the Oerlikon transformer, in which the loss of energy in the iron rose with an increasing load in a similar manner to the energy losses in copper.

The efficiency of the small Mordey transformer was found to be 94·5 per cent., and of the large converter 96·3 per cent.; that of the Oerlikon transformer at 100 periods was 94 per cent. at full load, and somewhat less at 50 periods; and of the Schuckert transformer the efficiency was 94 per cent. at full load.

WIRING CONNECTIONS FOR A DOUBLE MOTOR EQUIPMENT.

We give herewith diagrams showing the wiring and connections necessary for a car equipped with two Westinghouse No. 3 motors with type G controllers. Fig. 1 shows

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the entire wiring diagram for a car so equipped. Fig. 2 is a diagram showing the connections of the controller for both a single and a double motor equipment. Fig. 3 exhibits the arrangements of contacts provided upon the controller cylinder. The diagram on the left of Fig. 3 is for a single equipment, and that on the right for a double motor equipment. The first contact is made at the left in each case, and the movement is then toward the right for the successive points from 1 to 10. Fig. 4 represents in a diagrammatic form the 10 sets of connections produced by the arrangement of connections shown in Fig. 1. The first contact places the motors in series with all the resistance and with each other. In the second, part of the resistance is cut out, and in the third all, leaving only the two motors in series with each other. At the tenth step all resistance is out, and the two motors are connected in multiple. It will be noticed that no attempt is made to cut out a part of the field magnet coils at certain steps in the change from the start to maximum speed. The diagrams are reproduced from the *Street Railway Gazette*.

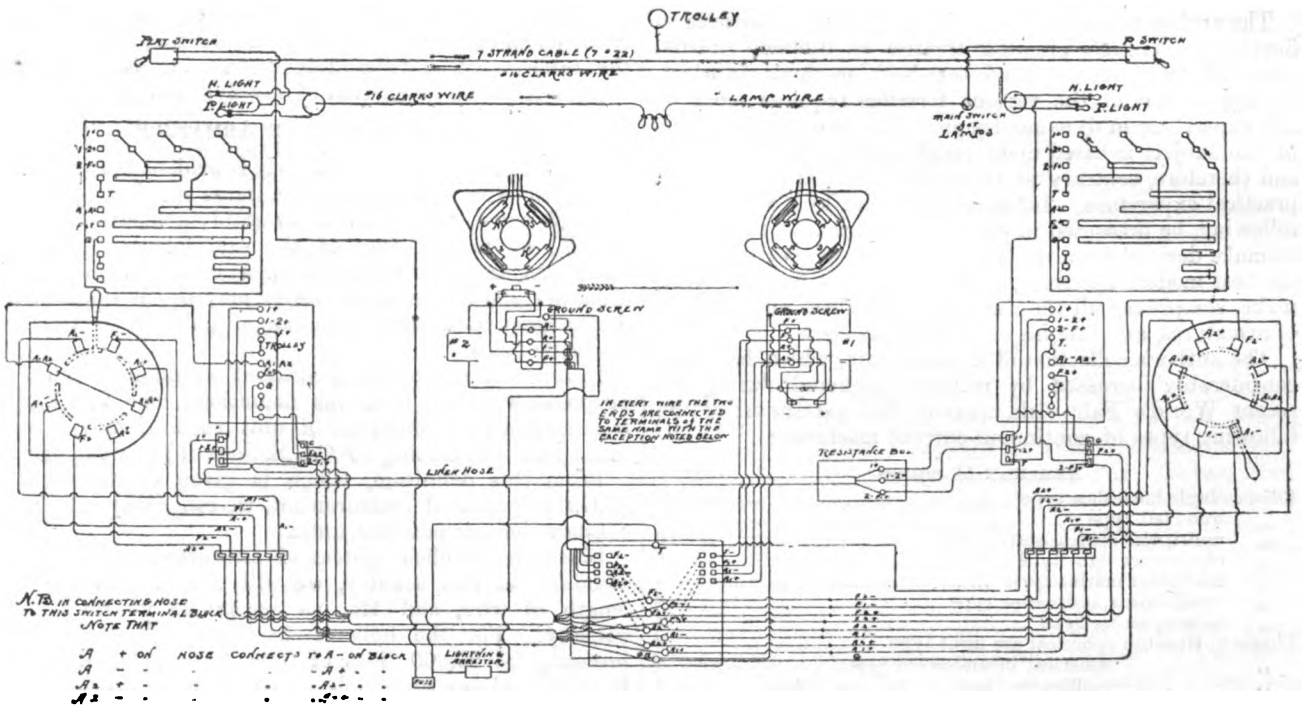

FIG. 1.—Diagram of Connections of Westinghouse Double Motor Equipment.

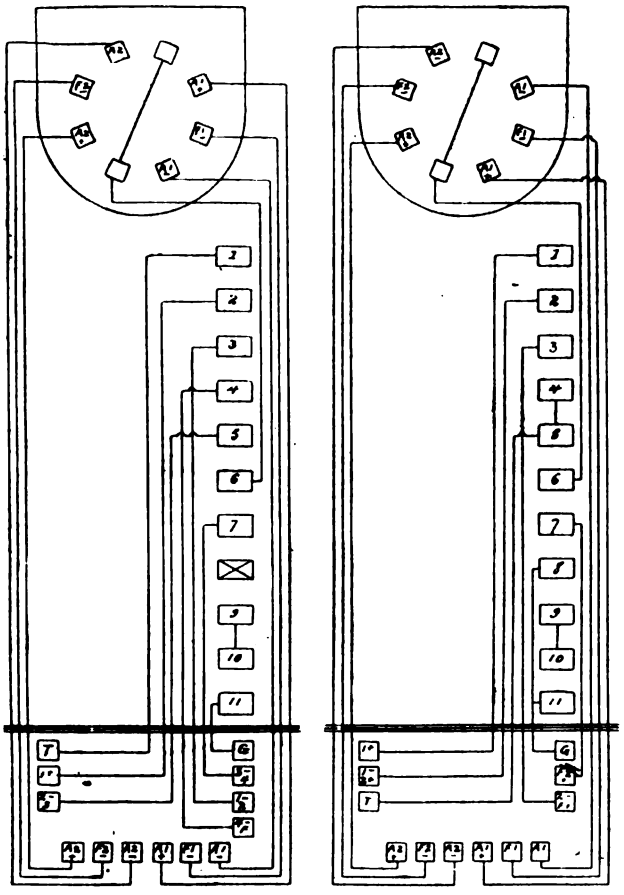

FIG. 2.—Controller Circuits for Single and Double Equipment.

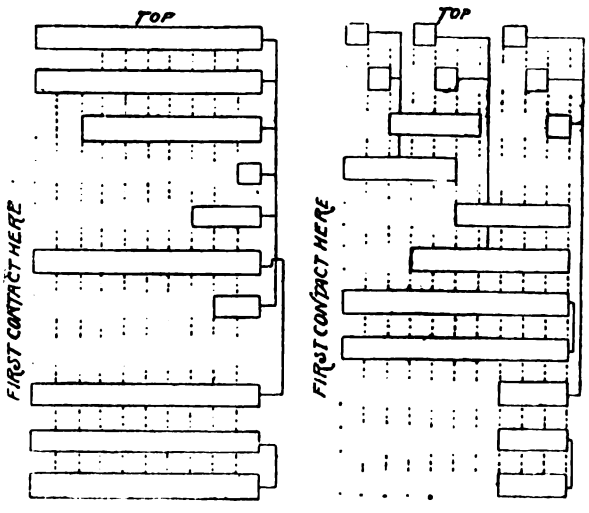

FIG. 3.—Controller Circuits for Single and Double Equipment.

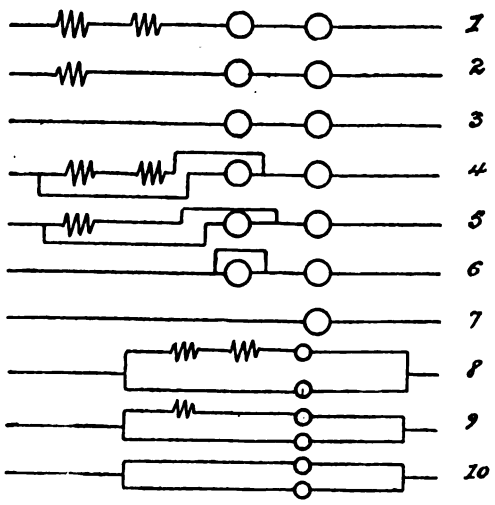

FIG. 4.—Motor Connections.

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PRACTICAL NOTES ON DYNAMO CALCULATION.—I.*

BY ALFRED E. WIENER.

The author has endeavoured in the following articles to develop an entirely practical treatise on dynamo calculation, differing from the usual text-book methods, in which the application of the various formulæ requires more or less experience in dynamo design. The present treatment of the subject is based upon results obtained in practice, and therefore, contrary to theoretical methods, gives such practical experience. Information of this kind will, in the following, be presented in the form of original tables and formulæ derived from the data and tests of nearly 200 of the best modern dynamos, of American as well as European make, comprising all the usual types of field magnets and of armatures, and ranging in all existing sizes.

The author's collection of dynamo data, which has been considerably increased by material gathered during his recent World's Fair visit, contains full particulars of the following types of continuous-current machines:

AMERICAN MACHINES.	Sizes.
Edison single-horseshoe type	20
,, iron-clad type	10
,, multipolar central-station type	10
,, bipolar arc light type	6
,, four-polar marine type	4
,, small slow-speed motor type	4
,, railway motor type	3
Thomson-Houston spherical arc light type	9
,, ,, spherical incandescent type	4
,, ,, multipolar type	3
,, ,, railway motor type	2
Brush double-horseshoe ("Victoria") type	16
Sprague double-magnet type	13
Entz multipolar marine type	5
Weston double-horsehoe type	3
Lundell multipolar type.	
Short multipolar railway motor type.	
Crocker-Wheeler bipolar motor type.	

ENGLISH MACHINES.	
Kapp upright horseshoe type	4
Paterson and Cooper "Phœnix" type	2
Mather and Platt "Manchester" type	2
Mather and Platt "Edison-Hopkinson" type	2
Paris and Scott double-horseshoe type	2
Crompton double-horseshoe type.	
Kennedy single-magnet type.	
"Leeds" single-magnet type.	
Immisch double-magnet type.	
"Silvertown" single-horseshoe type.	
Elwell-Parker single-horseshoe type.	
Sayers double-magnet type.	

GERMAN MACHINES.	
Siemens and Halske inner-pole type	3
Schuckert multipolar flat-ring type	3
Gülcher multipolar type	2
Fein inner-pole type.	
Fein iron-clad type.	
Fein inward-pole horseshoe type.	
Lahmeyer iron-clad type.	
Eickemeyer iron-clad type.	
"Allgemeine" inner-pole type.	
Bollmann multipolar disc type.	

FRENCH MACHINES.
Gramme bipolar type.
Marcel Deprez multipolar type.
Desroziers multipolar disc type.
Alsacian Electric Construction Company inner-pole type.

SWISS MACHINES.
Oerlikon multipolar type.
Brown double-magnet type.

In this list are contained the generators used in the central stations of New York, Brooklyn, Boston, Chicago, St. Louis, and San Francisco, United States; of Berlin, Hamburg, Hanover, Dusseldorf, and Darmstadt, Germany; of London, England; of Paris, France; also the General Electric Company's large power generator for the "Magic City" intramural railway plant, and other dynamos of fame.

In the author's possession, but not included in the above list, are, furthermore, particulars of various special designs, and incomplete data of generators and motors, too numerous to be mentioned. Besides these the author has at his command considerable data on alternating-current machines; but since the present treatise is to cover the ground of continuous-current dynamos only, no enumeration of the former has been made here.

The author believes that the abundance of his material entitles him to consider the following treatise, and especially the tables and data contained therein, as universally applicable to the calculation of any dynamo.

I. CALCULATION OF ARMATURE.

1. *Unit Armature Induction.*—It is evident that a certain length of wire moving with the same speed in magnetic fields of equal strengths will invariably generate the same E.M.F., no matter whether the said length of wire be placed on the circumference of a drum or of a ring armature, and no matter whatever may be the shape of the field-magnet frame or the number of poles of the different magnetic fields.

In order to obtain such a constant suitable for practical purposes, we start from the definition: one volt E.M.F. is generated by a conductor of unit length if moving with unit speed and cutting 10^8 C.G.S. lines of force per second.

From this definition, which is given in the absolute (C.G.S.) system of measurement, we can easily calculate a constant for our practical units.

Since the English system of measurement is still the standard in this country, we will take 1ft. as the unit length of wire, and 1ft. per second as its unit linear velocity. For the unit of field strength we take an intensity of 20,000 lines of force per square inch, this being a good average number occurring in practice, as can be seen from the table of practical field densities, which will be given later on.

Based upon these units, and upon the law: "The E.M.F. generated in a conductor is directly proportional to the length and the cutting speed of the conductor, and to the number of lines of force cut per unit of time," the derivation from the definition above referred to has been made in tabular form as follows:

Length of conductor.	Cutting velocity.	Density of field.	E.M.F. generated.
1cm.	1cm. per second.	100,000,000 lines per cm.^{2}	1· volt.
1ft.	,, ,, ,,	,, ,, ,,	30·48 ,, (1)
,,	1ft. ,, ,,	,, ,, ,,	929·03 ,, (2)
,,	,, ,, ,,	20,000 ,, ,,	·186 ,, (3)
,,	,, ,, ,,	,, per square inch	·0288 ,, (4)

(1) 1ft. = 30·48cm. (2) 1ft. per second = 30·48cm. per second; $30{\cdot}48 \times 30{\cdot}48 = 929{\cdot}03$. (3) $\frac{100,000,000}{20,000} = 5,000$; $\frac{929{\cdot}03}{5,000} = {\cdot}186$. (4) 1 square inch = 6·45cm.^{2}; $\frac{{\cdot}186}{6{\cdot}45} = {\cdot}0288$.

The result thus obtained can be worded: "Every foot of conductor moving with the velocity of 1ft. per second in a magnetic field of the density of 20,000 lines of force per square inch generates an E.M.F. of 0·288 volt."

If two or more equal lengths of wire are connected in parallel, in each of these lengths every foot of wire will generate ·0288 volt, but these parallel E.M.F.'s will not add, but the total E.M.F. generated in one length will also be the total E.M.F. output of the combination.

In an ordinary bipolar armature, now, there are generally two such parallel branches, each branch generating the total E.M.F. This necessitates 1ft. of generating wire in each of these two parallel circuits, or altogether 2ft. of wire, under our unit conditions, in order to obtain an E.M.F. output of ·0288 volt; or, in other words, every foot of the total generating wire on a bipolar armature, at a cutting speed of 1ft. per second, in a field of 20,000 lines per square inch, generates ·0144 volt of the output E.M.F.

In multipolar armatures the number of electrically parallel portions of the winding usually is equal to the number of poles, 2 P, the number of pairs of poles being denoted by P. In such armatures it therefore takes 2 P feet of generating conductor to produce ·0288 volt of output, or the share of E.M.F. contributed to the total output by every foot of the generating wire on the entire pole-facing circumference is $\frac{{\cdot}0288}{2\,P}$, or $\frac{{\cdot}0144}{P}$ volt—that is, ·0144 volt per pair of poles.

This theoretical value of the "unit armature induction,"

* From the *Electrical World*.

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however, has to undergo a slight modification for the practical use, owing to the fact that generally only a portion of the total generating or "active" wire of an armature is "effective." "Active" is all the wire that is placed upon the pole-facing surface of the armature, "effective" only that portion of it which is actually generating E.M.F. at any time—that is, the portion immediately opposite the poles and within the reach of the lines of force at that time.

The percentage of effective polar arc in modern dynamos, according to the number and arrangement of the poles, varies from 50 to 100 per cent., and usually lies between 70 and 80 per cent. The lowest values of the effective arc, 50 to 60 per cent. of the total circumference, are found in the multipolar machines made by Schuckert, with poles parallel to the armature shaft, and having no separate pole shoes; in these the space taken up by the magnet winding prevents the poles from being as close together as in machines of other types. The highest figure, 100 per cent., is met in some of the Allgemeine Elektricitäts Gesellschaft dynamos, in which the poles are united by a common cast-iron ring (Dobrowolski's pole bushing).

For these various percentages I have found the following average values of the unit armature induction per foot of the total active wire:

TABLE II.—Practical Values of Unit Armature Induction.

Percentage of polar arc.	E.M.F. per foot of active armature conductor per pair of poles at unit velocity (1ft. p.s.) and unit field strength (20,000 L. per sq. in.). Bipolar dynamos.	Multipolar dynamos.
1·00	·0144	·0144
·95	·0142	·0135
·90	·014	·013
·85	·0135	·0125
·80	·013	·012
·75	·0125	·0115
·70	·012	·011
·65	·0115	·0105
·60	·011	·010
·55	·0105	·0095
·50	·010	·009

It will be noticed that the values for multipolar machines run somewhat below those for bipolar ones. This means that, at the same rate of polar embrace, a greater percentage of the total active wire is effective in the case of a bipolar machine, which is undoubtedly due to a greater circumferential spread of the lines of force in bipolar fields.

2. *Specific Armature Induction.*—Knowing the values of the induction per foot of active armature wire at the assumed unit conditions, a general expression can now easily be derived for the "specific armature induction" at any given conductor speed and field density. The induction per foot of active conductor in any armature is:

$$V = \frac{v}{P} \times S \times \frac{F}{20{,}000} \quad . \quad . \quad . \quad . \quad (1)$$

where V = specific induction of active armature conductor, in volts per foot;

v = unit armature induction per pair of poles in volts per foot, at S = 1ft. per second, and F = 20,000 lines per square inch, from Table II.;

P = number of pairs of magnet poles;

S = cutting speed, or conductor velocity, in feet per second, from Table III.;

and F = field density, in lines of force per square inch, from Table IV.

In this formula it is supposed that, as is usually the case, the number of electrically parallel circuits in the armature corresponds to the number of magnet poles. If these two numbers, however, are not identical, half the former number is to be substituted for P.

(To be continued.)

Auffay.—This little town in the Seine Inférieure is lighted by electricity. Current is supplied by a Postel-Vinay dynamo, driven by a Hercules turbine.

INSTITUTION OF CIVIL ENGINEERS.

The annual general meeting to consider the report of the outgoing council, with the statement of accounts, and to elect the council and officers for the ensuing session, was held on Tuesday, Mr. Alfred Giles, the president, being in the chair.

The tabular statement of the transfers, elections, deaths, and resignations during the year showed an effective increase of 188 on the previous total of 5,371, or at the rate of 3½ per cent. per annum, while as regards the students the decrease was 28. The gross numbers on the books on March 31 in 1893 and in 1894 were 6,397 and 6,557 respectively.

A review of the work of the past session was next given, from which it appeared that 19 papers had been read and discussed at the ordinary meetings, treating of separate and clearly defined branches of engineering—municipal, hydraulic, mechanical, mining, and electrical—and also referring to naval architecture. For several of the papers detailed premiums had been awarded to Messrs. Clerke, Kreuter, Vernon-Harcourt, Partiot, Greathead, Fox, Parker, Hunt, Redwood, Commans, and Colquhoun. The papers selected for printing without being read had been numerous and varied, and had ranged over the whole field of modern engineering. Mention was made of several representative memoirs in the various branches, not that they merited greater recognition than the others, but that they served to support the quality of catholicity claimed for the institution. Premiums for papers in this category had been awarded to Messrs. Donkin, Lowcock, Marks, Tanabe, Ewart, and Moncrieff.

The second of the "James Forrest" lectures had been delivered by Dr. John Hopkinson, F.R.S., M.I.C.E., his theme being "The Relation of Mathematics to Engineering." This recondite subject has been presented to a large audience, which testified in a marked manner its appreciation of the lecture.

Eleven supplemental meetings for students had been held. For papers read by students at the institution, and before the local associations, the council had made the following awards: the Miller scholarship (tenable for two years) to Mr. L. H. Appleby; and Miller prizes to Messrs. A. R. Gale, W. Beer, W. G. Wales, H. T. White, P. J. Tucker, H. N. Alliott, A. Watson, W. O. Leitch, and T. H. Watt.

The ballot for council resulted in the election of Sir Robert Rawlinson, K.C.B., as president; of Sir B. Baker, K.C.M.G., Mr. J. W. Barry, Mr. W. H. Preece, C.B., and Sir Douglas Fox as vice-presidents; and of Dr. W. Anderson, A. R. Binnie, W. R. Galbraith, J. H. Greathead, Sir Chas. A. Hartley, K.C.M.G., J. C. Hawkshaw, C. Hawksley, Dr. Alex. B. W. Kennedy, Sir Bradford Leslie, K.C.I.E., J. Mansergh, Sir Guildford Molesworth, K.C.I.E., Sir E. J. Reed, K.C.B., W. Shelford, F. W. Webb, and Dr. W. H. White, C.B., as other members of the council.

The session was then adjourned to the second Tuesday in November.

Steam-Engines for Electric Lighting in Germany.—The Statistical Bureau for Prussia have published figures relating to the employment of steam-engines in the production of electricity in the kingdom. There has been a large increase since 1891. At the beginning of that year there were 983 fixed and portable steam-engines of a total of 49,489 h.p. thus employed. At the commencement of 1892 there was an increase to 1,199 engines of 66,803 h.p., and at the commencement of 1893 to 1,407 engines of 76,045 h.p. Of 1,218 engines, which at the beginning of 1893 were solely used for electricity purposes, 1,089 engines of 48,692 h.p. were used for lighting only, and 14 engines of 1,286 h.p. for transmission of power purposes only. There were 94 engines of 15,336 h.p. used both for lighting and power transmission, and 21 engines of 1,214 h.p. for electrolytic, electrotyping, chemical, and other purposes. Rhineland stands at the head of the Prussian provinces, and is followed by the city of Berlin as regards the number of engines, but the latter is first as regards horse-power.

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THE
ELECTRICAL ENGINEER.

Published every Friday.
Price Threepence; Post Free, Threepence Halfpenny.
Editorial and Publishing Offices:
139-140, SALISBURY COURT, FLEET STREET, LONDON, E.C.

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TO CORRESPONDENTS.

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All communications intended for the Editor should be addressed C. H. W. Biggs, *139-140, Salisbury Court, Fleet Street, London, E.C. Anonymous communications will not be noticed.*

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STILL EXPERIMENTAL RUBBISH.

We are afraid that we do not altogether agree with the conclusions of Mr. Bridgman as regards the advisability of local authorities experimenting. At any rate we should have very strictly to define what is meant by experimenting. No one would at this stage of the investigation, for example, urge a local authority to attempt to light the streets and houses by means of static electricity after the manner of Tesla. Scientific opinion is not satisfied that such a course is feasible; but when it comes to the lighting of a town by means of the ordinary dynamo and its accessories, upon that scientific opinion is decided. To attempt the one would be rash experimenting; to attempt the other would savour of wisdom. Mr. Bridgman seems to imply that the wisdom of the local legislature is shown by waiting, purchasing at a fair valuation when private individuals have proved the matter under consideration to be successful. Applied to electric lighting, this means that, in Mr. Bridgman's opinion, it is better to let private individuals exploit for twenty years or so to show that the undertaking has passed the experimental stage, and then the authorities may safely purchase. We suppose the oft-told tale of Hugh Myddleton and the New River was intended to point the moral, that too early taking part in an undertaking might mean failure, while purchase at the proper moment might mean a gigantic success. We object to this principle applied to electric lighting. The success in the future may be out of all proportion to the success of the present. Fortunately for the local bodies, unfortunately, as many think, for the successful companies, the Legislature has enacted that after a certain period there may be a compulsory purchase of the undertaking. It is pretty certain that, in the usual order of things, when the time of permissible compulsory purchase come round, the undertakings, though they may have been successful, may have recouped the outlay spent upon them, will in no way be said to have reached maturity. The end and aim of central-station lighting will be to light all the streets and houses in the district, and till the very last room is lighted it is impossible to say exactly how great the success, or, rather, how large a return may be obtained. It is impossible in the course of a few years to oust all rivals, or, in fact, to make a very great impression on some rivals; hence development, which in one district may be slow, may in another be very rapid. We have for several years contended that electric lighting has passed the experimental stage; that under ordinary conditions it should pay its way within a year or two, and subsequently the balance-sheet will go on getting better. It is for the general welfare of the community that artificial light should be obtained at the lowest possible cost, and it can only be so obtained when the authority is the undertaker. Had the Corporation of London financed Hugh Myddleton, the City would at this moment have possessed an asset said to be worth twenty millions of pounds. Myddleton was ruined, but he could foresee the valuable nature of his work, and had his contemporaries possessed his foresight

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we may be sure that the New River, instead of being as it is now, would have been a municipal undertaking. We object to a municipal body becoming middlemen. We do not ask them to become grocers, tailors, or tallowchandlers, but we do think that in all matters relating to light and water, among other things, they should provide for the community, and not let their interests merge into the hands of private individuals. The crux of the whole question Mr. Bridgman will say is in emergence from the experimental stage. The time of that emergence is a matter of opinion. We can, if we like, argue even now that the steam-engine is an experimental machine and not a perfect piece of apparatus. There is no denying the fact, but had civilisation waited from the time of its inception till now for the perfect machine and the end of experimenting, we should have a far different state of affairs in the world than at present exists. This indefinite view of what is experimental and what is not, has an evil effect upon electric light undertakings. It is very easy to cry "experimental"—very difficult to counteract that cry. "Let him prove that it will pay," is the usual cry, instead of ascertaining what is wanted, writing a specification, and paying of the work according to specification. From our point of view the objection to waiting local or municipal enterprise is that even when convinced of utility, possibility, desirability, and successfulness, there is always too much procrastination. The work is not always proceeded with on its merits, but is the shuttlecock of party warfare. Let us do our best to dispel all ideas of putting off because "electric lighting is still in the experimental stage." It isn't; and it will prove of advantage to authorities if they take the matter into their own hands, rather than permit private enterprise to create "vested interests." Depend upon it, when the time for compulsory purchase comes round, if the work is fairly successful, there will be a legal way of getting its proper value. What that proper value will be is perhaps as proportionate to its actual cost, as the value of the New River shares is to their par values.

CORRESPONDENCE.

"One man s word is no man's word,
Justice needs that both be heard."

ELECTRIC LOCOMOTIVES IN FRANCE.

SIR,—I noticed in your issue of last week an item to the effect that the Paris, Lyons, and Mediterranean Railway Company are building a considerable number of new locomotives, both steam and electric. The compound steam locomotives on this line have already obtained prominence on account of their excellent design and good working results, and I presume that the new ones are additional engines of the same or improved type. I do not, however, quite understand, with regard to the electric locomotives, how the first of the two types you name can be an "electric locomotive" when the electric motor is installed, as stated, on the rolling-stock. There is all the difference in the world between a locomotive and a motor car, instances of which may be seen respectively on the South London and the Liverpool Overhead lines, and I would be sorry to see the technical journals transgressing in accuracy of language, seeing that it is their duty rather to guide in this respect those of us who are actively engaged in the industry. The second type of electric locomotive which you mention presents features of great interest, and I shall look forward to more details of it in due course. At present I cannot do more than express my surprise and pleasure at finding any railway company who will undertake the construction of no less than 60 electric locomotives of an output equal to at least 400 h.p. apiece. Moreover, the particulars you give would lead me to think that these engines are intended for freight service, and not to work the high-speed passenger trains, as has hitherto been supposed.

Perhaps you will be able in due course to publish more particulars of these locomotives. I am sure that a detailed description thereof would prove of great interest and value.

Yours, etc., LOCO.

May 28, 1894.

A CITIZEN'S OPINION OF ELECTRIC LIGHTING.

A large number of guests assembled on Thursday of last week at a banquet at the Cannon-street Hotel, given by the Commission of Sewers, to meet the Lord Mayor and Sheriffs, and to do honour to the late chairman, Mr. H. H. Bridgman, F.R.I.B.A. The chair was taken by Alderman Bell, F.R.G.S., who was supported on his right by the Lord Mayor, and on his left by Mr. Bridgman. After various toasts had been honoured, the CHAIRMAN proposed the toast of the evening—namely, "The Health of the Past Chairman." He said that it was usual for the colleagues of the chairman on his retirement to present him with some recognition of their appreciation of his year's work, and the honour of making the presentation to Mr. Bridgman that evening had been placed in his hands. A full-sized portrait in oils of Mr. Bridgman, painted by Mr. Manton, was then unveiled, and the Chairman said that on behalf of his colleagues and himself he had very great pleasure in presenting it to Mr. Bridgman, accompanying the gift with a fervent hope that Mr. Bridgman would long be spared to pursue his duties on the Corporation and the Commission of Sewers.

Mr. H. H. BRIDGMAN, in acknowledging the compliment that had been paid him, said: "You have been kind enough, sir, to designate this toast 'the toast of the evening.' I need hardly say how greatly I appreciate the compliment. I thank you much for your kindness in proposing the toast of my health in such unmeasured terms, nor do I fail to appreciate the generous reception which has been given to it by this distinguished assembly. I have for a long time thought it a great pity that so much of the City's past history should lie hidden in obscurity, as it were, for the want of a ready reference enabling one to alight at once upon any and every incident of interest in that history. This it is my intention to supply, and when the facts are briefly annotated in chronological order, innumerable interesting events could, without any trouble, be referred to and enlarged upon, which will, I am sure, awaken a livelier interest than even now exists in the past and present history of the Corporation, and correct any erroneous impression that may exist. As an instance of erroneous impressions, I would mention that I had long entertained the idea that the Corporation's interest in that mine of wealth, the New River enterprise, was lost to the City and Metropolis by some laxity on the part of the Corporation, and many still think so, but I am pleased to find it is not so. My theme to-night, however, if any, should be the Commissioners of Sewers, which had its origin also in the Tudor times, about half a century after the events just referred to. I have nothing to say but in the highest commendation of the manner in which the work is now performed. I do not believe the work could be done better in whosever hands the duties might be placed, and such is the result only of experience. To illustrate this I will only refer to one aspect of the Commissioners' work, and that is the businesslike and sensible manner in which the electric lighting of the City has been dealt with. The City has been rebuked for not undertaking the task of providing its own complete installation and plant for public and private lighting—so much so that a newspaper stated very recently that whereas the cost of the public lamps in St. Pancras—my own parish—where the lighting has been done by the

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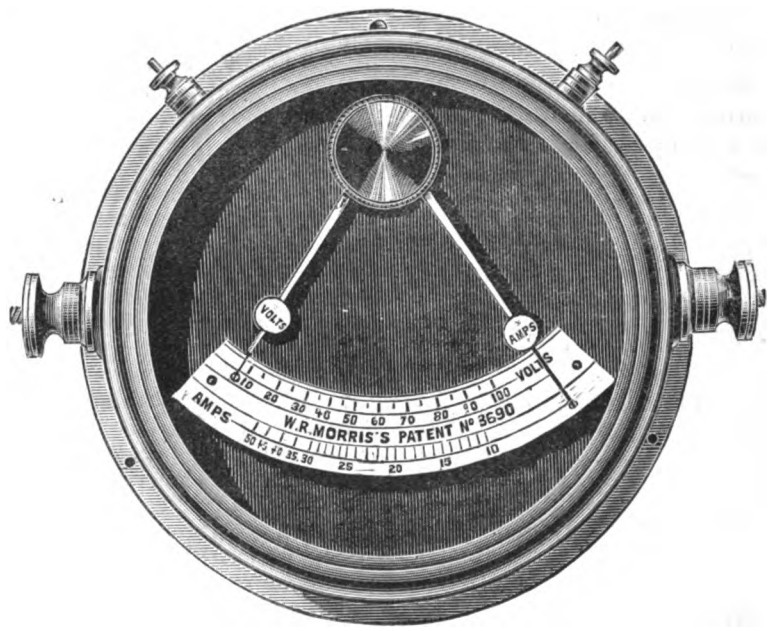
Vestry, is £17 per lamp, yet in the City, where it has been done by a company, it is £27 per lamp, and that St. Pancras had solved the problem of the cost of public lighting by electricity. What are the facts? I showed conclusively, in answer to that statement, that the lighting in the City costs 31 per cent. per lamp less than St. Pancras, all things considered, even supposing the £17 per lamp to be correct; but that even is not so. Prof. Robinson, who has charge of the St. Pancras lighting, has stated in public that the cost per lamp was £23 for only a part of last year. That means that the lighting of the public lamps in St. Pancras is more than 60 per cent. at least beyond the cost of the City lamps. This fact, I think, speaks volumes for the sagacity and foresight exercised by the Commission, who, I am proud to say, have acted on the principle that it would be wrong, at the present time at least, to expend a million of the ratepayers' money in experimental enterprises; but that such undertakings, speculative and hazardous as they must be, are better left to those who might do what they choose with their own money. The City and other authorities as well have the right by Act of Parliament at the proper time to buy such undertakings at a fair and reasonable price, if they think it desirable.

A COMBINED AMMETER AND VOLTMETER.

The instrument illustrated herewith consists of a strong brass case, 8in. in diameter, provided with four terminals.



The two small terminals are used for the volts and the two large terminals for the amperes. The instrument has two pointers; on one pointer is arranged a disc with the word "volts," and on the other a disc with "amperes" on it. By this plan no mistake in the readings can occur. It will be noticed in the illustration that the disc on one pointer is higher than that on the other. This arrangement allows both discs always to be seen, as one disc cannot come in front of the other and eclipse it. Another feature of the instrument is the double scale. The top part is used for the volts, reading from left to right, and the bottom part is utilised for the amperes, reading from right to left. It is not very easy to look at two instruments at the same time, even though they may be placed side by side, but in this instrument what is going on can be seen at a glance, and by multiplying the reading of one pointer by that of the other, the number of watts being used is at once obtained. This makes the instrument, as it were, also a wattmeter, as each pointer is separate and distinct. It can be used separately as a voltmeter or as an ammeter, as the volt and ampere circuits are entirely insulated from one another. No pointed dials are used, each scale being marked by hand during calibration and afterwards engraved. This method is claimed to prevent any errors caused by the use of printed scales or dials.

The principle of the instrument is the action of a solenoid on a suitably suspended piece of iron wire (which weighs only a few grains), and as there are no permanent or electro magnets or springs used, the instruments, as stated, never require recalibrating. The instrument is a gravity one and direct reading, and can always be left in the circuit. To use the instrument it is screwed up vertically, so that the hands point to zero. The two small terminals are connected across the mains, and the two large terminals are connected in the circuit; the current and the E.M.F. will then be indicated at the same time. This instrument has been devised by Mr. W. R. Morris, of 34, Livery-street, Birmingham.

ELECTRIC POWER IN IRON AND STEEL INDUSTRIES.

In our issue of the 11th May was given an abstract of the paper presented to the Iron and Steel Institute by Mr. D. Selby Bigge, on "Electricity as a Motive Power in the Iron and Steel Industries." The same gentleman recently read before the Cleveland Institution of Engineers a paper on "Electric Power in Iron, Steel, and Engineering Works," and before the discussion commenced at a meeting of the institution on May 21, the author supplemented his paper by a few remarks. He stated that since his paper was read he had had opportunities for investigating more closely the possible applications of electric power in iron, steel, and engineering works generally. There was, he thought, no difficulty in applying electric driving to the whole of the auxiliary machinery usually found in these works, but the lines on which the electric power station should be laid down and the methods to employ for the distribution of the electric energy required most careful consideration. In his paper he had laid great stress on short-distance transmission and concentration of power. He then explained certain diagrams showing the method of working in an establishment where the machinery was worked by steam, and the same establishment with electric power introduced. In the first boilers and engines were scattered all over the works, but in the second the power was concentrated, and could be distributed with the greatest ease and with little loss throughout the manufactory. The coal consumed in connection with the electric power was but a small portion of what had been expended in the old works, and where they had available—as at the Cleveland furnaces—waste gases as fuel, the cost was small indeed. The speaker then

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drew attention to a diagram showing the load line of a motor when running a shop in which a large number of small lathes, drilling and milling machines were at work, and it was curious to note that more power was absorbed when the whole place was running light than when the normal work was going on. This would appear paradoxical at first sight, but it must be remembered that during normal working a large number of the machines were being stopped and started very frequently. This experiment was repeated in different shops of a similar character and with different motors, and always with like results. In referring to the application of electricity to rolling mills, he had stated in his paper read before the Iron and Steel Institute that he did not refer to the heavier class of rolling mills which absorbed several thousand tons of horse-power, but he firmly believed that as regarded the lighter class of mills there was a future for the application of electric power, the great advantages to be derived being the large economy which could be effected in coal consumption and wages. He would like to cancel that statement as to not referring to the heavier class of rolling mills. He had since discussed that question with several engineers conversant with rolling-mill practice, and he had now come to the conclusion that rolling mills could and would be operated electrically, as there were several very great advantages to be derived from such a course. Taking the case of large rolls revolving at, say, 50 or 60 revolutions per minute, the application of the motor might be made through large worm gear. In smaller mills—*i.e.*, where lighter material was being rolled—the motor might be applied direct with a flexible coupling to the rolls. The greatest difficulty in the application of electricity to rolling mills would, the speaker thought, be found in the switching and reversing gear. The motors also would have to be constructed and wound to meet the large rushes of current which would take place, and the collecting brushes would have to be of special design. At Messrs. Dorman, Long, and Co.'s works, Middlesbrough, where electric motors had been applied, there had been a saving of 30 tons of coal per week, as compared with the same machines when steam driven. Taking the National Arms Factory at Liège, where was one of the finest examples of the application of electric power, they had produced rifles at the rate of 1½ h.p. per rifle, whereas at works run by steam in the ordinary way it took 3¼ h.p. to 3½ h.p. There were there 1,500 to 1,800 machine tools at work. At another factory which adopted electricity in place of steam, five or six steam-engines and four boilers were replaced by one engine and one boiler, and the dynamo. The coal consumption before and after its adoption was taken, and it was found that what formerly required an expenditure of three tons daily now needed only one ton. About that ratio had been reported in other cases. As to the efficiency which had been obtained at the National Arms Factory at Liège it amounted to 71·3 per cent. of the indicated horse-power of the engines in useful work. In another works it was 75·5 per cent., and in another 68·5. There was another point in laying down new works or extending old ones engineers would have to consider—the embodying of the electric motor in the actual machine tool, and not to apply it to the shafting.

"UNKNOWN" CAUSES OF FIRE.

BY H. C. CUSHING, JUN.

Every fire which takes place in any city of considerable size is recorded as to location, loss, amount of insurance carried, and the cause, or supposed cause, of the fire. In the city of Boston there were, during the year 1893, 1,233 fires, with a loss of 5,024,765·04dol. Twenty per cent. of all these fires are from unknown causes. When these unknown causes cost property owners more than 1,004,955dol. it is about time that some investigations were made beyond attributing these causes to spontaneous combustion, incandescent or arc light wires, or to any other wires which enter a building. When an inspector cannot satisfy himself that it was from the stoves, careless use of kerosene or matches, it is a very easy thing to lay it to spontaneous combustion or the unfortunate electric light wires.

The person attributing fires to the electric light wires being crossed with some trolley or other high-potential wire outside is probably not aware that every wire entering a building is thoroughly protected at its entrance by a fusible metal which will blow out at any overcharge, thus deadening every wire in the building; and, moreover, there would have to be a decided ground within the building, which is nowadays a very rare occurrence, as the writer's investigations have proved that out of 25 prominent buildings in the city of Boston the insulation resistance to ground proved to average over 2,000,000 ohms. But when I say that the electric light and power wiring should not receive the blame as often as it does, I do not mean to take the responsibility off electricity, for it is through this agent that I have reason to suspect the origin of many of the "unknown" causes, so-called, on fire reports.

When electricity is allowed to roam at large and in vast quantities all along our water and gas pipes and through the ground upon which the city is built, in order to get back to the sources at which it was generated, which are the street railway power stations, it is this state of affairs which is creating a trouble, the extent and seriousness of which is only known to those few who have made it a study. These street railway power stations, operating the overhead trolley system, are constantly generating thousands of electrical horse-power, sending it out by overhead trolley and feed wires to the cars which it operates, and returning it to the station by means of the water and gas pipes which lie in its course. For this reason there is a tremendous electrolytic action going on all the time. The writer has samples of gas and water pipe completely eaten through by electrolytic action in three months after having been placed in the ground near street railway returns.

Whenever this returning current flows in any quantity along a pipe there is bound to be a large fall of potential, varying in different pipes as their carrying capacity increases or diminishes. In the cellars and basements of many houses I have found quite a large difference of electrical pressure between two pipes entering within 1ft. of each other, and, in one instance, it was a very easy matter to take a piece of hoop iron and draw an electric arc sufficient to ignite a piece of waste held near it; and by connecting these pipes together with a piece of No. 18 copper wire, the current flowing through it was sufficient to heat it so that it was impossible to lay one's hand upon it. In the basement of another building within the city limits, I find a man using 25 amperes at eight volts pressure, or electricity enough to run small motors and incandescent lamps, as well as all the electrical bells in the entire building, by simply twisting his wires around two different water-pipes which enter the building. Some time ago my attention was called to two pipes which were so close together that the vibration of an elevator engine caused them to knock together just sufficient to create an arc every time a contact was made and broken. This had been going on so that it had almost completely eaten through the gas-pipe, and it is perfectly evident what would have taken place had this been allowed to go on unobserved. The gas would have been ignited by the electric spark as soon as the first small hole appeared, and disastrous results would have undoubtedly followed.

This difference of electrical pressure between water and gas pipes is now so well known that in a number of cases in the cities of Boston and Cambridge the ordinary electric bell battery is entirely discarded, and the wires from the bells connected directly to water-pipes, the latter furnishing an inexhaustible supply of electricity at the proper pressure to run any number of bells or gas-lighting apparatus, and also to do any quantity of mischief. I can see no reason why fires should not be attributed to this cause, when it can be proved that such a difference of electrical pressure really does exist between any two pipes entering a building in the vicinity of the trolley system of street railways.

There is only one way of eliminating this rapidly increasing danger, and that is by compelling the electric street

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railway companies to insulate from the ground their entire electrical circuit, and just as soon as a suit for damages is brought by the water and gas companies for systems of pipes destroyed by electrolysis, the railway companies will begin to remedy the evil, which they are more fully aware of than anyone else.—*Electrical Engineer* (New York).

ELECTRIC LIGHT PROJECTORS.

There is no doubt that the use of electric light projectors is progressing. The total number now in use is many thousands, and an approximate idea can be obtained from the fact that since 1877 there have been sold 2,800 Mangin projectors and 300 parabolic projectors. They are efficaciously utilised in the defence of coasts and passes, as well as for port services. Navies have bought a large proportion in connection with the protection of cruisers for the night attacks of torpedo-boats. The first apparatus employed for electric projectors consisted of parabolic mirrors of polished and silvered metal, but under the influence of damp air, salt water, and so on, the polished surface rapidly deteriorated. Fresnel therefore substituted lenses consisting of glass rings, so combined and arranged as to produce good results, but the apparatus was very dear and required delicate handling, especially when the dimensions were at all large. Since then progress in the glass industry has enabled us to obtain glass mirrors of large surface. Such have been manufactured in Germany and by Messrs. Bréguet in France, and are generally obtained by bulging a sheet of glass. These parabolic mirrors are employed concurrently with spherical mirrors made by Messrs. Sautter-Harlé from an idea of Colonel Mangin. This mirror consists of a cap of glass cut on its two faces according to two spheres of unequal radius, and silvered on its concave face. Both forms of projector have advantages and disadvantages. The Mangin spherical mirror has not the geometrical form to assure the parallelism of the rays. Only parabolic form allows of this condition being realised, and a perfect parabolic mirror of exact mathematical curvature would evidently be superior to any other, especially if the source of illumination were reduced to very small dimensions—theoretically to a point. This condition not being realised in practice, the parabolic mirror consequently loses a part of its advantages.

It is also stated that up to the present the parabolic curvature has not been obtainable with the same precision which can be arrived at in spherical mirrors. Taking the Mangin mirror to have an efficiency of 7 to 8 per cent. less than that of a theoretically perfect parabolic mirror, this disadvantage is mostly compensated for by a diminution in the errors in construction, so that the two may be considered equal as regards lighting power. It is possible with spherical mirrors to employ less intense illumination, thereby effecting an economy in electrical energy. As regards weight, the spherical mirrors are by far the heavier. They are consequently best suited for resistance to shocks and vibration, and for use in lighthouses, for the defence of coasts, passes, ports, and for large vessels, while the lighter parabolic projectors are of more service for moving defence, for packet-boats, where a reduction in dead-weight is desired, and for army use during a campaign.—*Revue Scientifique.*

Alternating-Current Motors.—In a recent issue of the *Annales des Mines* M. Walckenaer deals with the question of the employment of alternating-current motors. The author examines successively the principles upon which the various types of this form of motor are based, and then describes a recent application of a distribution of electrical energy by two-phase currents in the Decize mines, carried out by the Creusot Works. This installation comprises a transmission of electrical energy over distances ranging from one to about three miles, and the current is used for operating hauling machinery, ventilators, and for lighting purposes.

A NEW SIMPLIFIED METHOD FOR CALCULATING POLYPHASE ALTERNATING CURRENTS.

In a recent issue of the *Comptes Rendus*, M. A. Blondel describes a simplified method for calculating polyphase alternating currents. An abstract of the article is given in the *Journal* of the Institution of Electrical Engineers.

The author's object is to render the calculations of polyphase currents as simple as those of monophase currents.

The method starts with the two following hypotheses:

1. That alternating currents all vary according to some harmonic law.

2. That the rotating magnetic field produced by a system of harmonic polyphase currents, symmetrical both in intensity and phase, as, in virtue of the good design and secondary reactions of the machine, an intensity and an angular velocity sufficiently constant that the flux cut by any one of the polyphase windings should vary also according to some harmonic law.

From these hypotheses the two following statements may be made:

1. A rotating magnetic field may be represented by a vector, representing the direction in which the induction is a maximum at any given moment, and also the constant value of this maximum.

2. The polyphase currents producing it may also be collectively represented by a single vector, standing for the intensity of an equivalent rotating current passing round the whole circuit; in the same manner the whole of the alternating E.M.F.'s may be representing by a single rotating E.M.F., or vectorial. If q be the number of polyphase currents employed, I_0 their maximum amplitude, U_0 their maximum tension measured between each conductor and the return conductor, then the vectorial intensity, I, and the vectorial tension, U, may be defined as by formulæ (1) and (2):

$$I = I_0 \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$U = \frac{q}{2} U_0 \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

The value, ϕ, of a field may always be expressed in terms of the vectorial intensity, I, of the system producing it, and so also the vectorial E.M.F., E, as a function of a field, F, which is producing it, by means of the two expressions:

$$\phi = \frac{\pi}{R} I K \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

$$E = \frac{k}{4} \frac{2\pi}{T} N F \quad . \quad . \quad . \quad . \quad . \quad (4)$$

where R is a magnetic resistance, K and k two coefficients depending on the type of winding.

By comparing the two formulæ (3) and (4) one obtains the theoretical expressions for the coefficient of mutual induction, M, of two polyphase systems, and of the self-induction, A:

$$M = K k \frac{4\pi}{R} \frac{N_1}{2} \frac{N_2}{2} \quad . \quad . \quad . \quad . \quad (5)$$

$$A = K k \frac{4\pi}{R} \left(\frac{N_1}{2}\right)^2.$$

The above simple definitions will allow of the application of all the ordinary laws and graphical methods used in the case of monophase alternating currents to vectorial currents.

UTILISATION OF REFUSE IN CHELSEA.

The following is the report presented to the Vestry of Chelsea by their surveyor, Mr. T. W. E. Higgens, on the dust destructor at Kensal Town.

In accordance with the Vestry's resolution on March 20, I have been in communication with several firms as to the erection of a dust destructor at Kensal Town. In my report of that date I said "in or near" Kensal Town; but the resolution which was passed on April 3, asking the Baths Commissioners to give the use of their land for dusting purposes, seems to me clearly to indicate that the

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Vestry intend a portion of the Baths Commissioners site to be used for this purpose. Schemes have been submitted by (1) Messrs. Horsfall, (2) the Municipal Appliances Company, (3) Messrs. Manlove, Alliott, and Co., (4) Livet's British Steam Generator Company.

Messrs. Horsfall's Scheme.—It is proposed to erect three hand-fired cells, to fix a boiler 12ft. long and 7ft. in diameter, with a chimney 60ft. in height. Two estimates are submitted: the first, for iron buildings, and without a roof over the tipping floor, amounts to £1,873; while the second estimate, for substantial brick buildings and roof over furnaces and tipping floor, amounts to £2,273. But in both these estimates foundations to a depth of only 18in. below the ground are provided for, and no provision is made for the paving on the tipping floor or in front of the furnaces. Messrs. Horsfall, whose destructor at Oldham has been examined by the Dust Disposal Committee, intend to use a forced draught, but state that by introducing it at the back of the furnace, they will be enabled to put a stop to the noise caused by the steam jet. The opinion that the noise caused by the forced draught might be minimised by proper arrangement of the inlet, was lately expressed by Mr. Crompton in a paper read before the Society of Electrical Engineers. The three cells will burn 22½ tons per day, and the makers will guarantee 45 i.h.p. all the time the cells are in full work, reckoning 20lb. steam per indicated horse-power per hour at 80lb. pressure equals 90 gallons water evaporated per hour. If three hand-fired cells are used, one man to each shift of, say, eight hours will be required.

The Municipal Appliances Company's Scheme.—In this scheme four cells are provided with chimney 150ft. high, and two steam generators of about 70 h.p. collective when three furnaces are in use; the furnaces are sunk so that a clinker lift and two silent blowers will also be provided for the furnaces. Brick walls will be built to the sheds, and they will be roofed with galvanised iron roofing. The roadway is to be paved with 4in. granite cubes, and blue brick paving is to be laid in other places where necessary. Boundary walls on the canal bank and at the east end are also estimated for. The total estimate amounts to £4,086. This firm, however, have on a former occasion submitted a scheme to the Bath Commissioners, and they state they are prepared to modify that scheme, and construct four furnaces and three boilers with all necessary works, except boundary walls, for £4,812, but if the furnaces were sunk to a depth of 4ft. the cost would be £4,895. If in the latter scheme four Thwaite boilers, giving 30 h.p. each, were used the total cost would be £4,975.

Messrs. Manlove and Alliott's Scheme.—A two-cell destructor to be built of the kind known as Fryer's improved patent, with chimney 120ft. high. One double fume cremator (Jones's patent) and also forced air blast to be provided, also one multitubular steam-boiler 11ft. long and 6ft. in diameter, and auxiliary furnace for coal firing. An elevator will be used for raising the refuse to the top of the destructor, and a 4-h.p. vertical engine will be fixed for working it. The sides and roof of the buildings will be of corrugated iron. The estimate is £2,937, but this does not include the foundations. If a wrought-iron chimney, lined with firebrick, mounted on brick base, were substituted for the brick chimney, the cost would be £2,437, without foundations.

The British Steam Generator Company's (Livet's) Scheme.—Mr. Cheesewright, their engineer, writes: "If 84 tons of dust-bin or trade refuse be screened, an installation precisely similar to the one at Halifax would be ample for the work you want it to do, and would generate steam sufficient to give 120 i.h.p. for 144 working hours. The approximate cost of the Livet's generator, brickwork and furnace complete, would be £1,200—this is exclusive of chimney and other buildings. A royalty for the use of the patents of, say, 9d. for each and every ton of refuse or rubbish destroyed will be charged, this royalty to be payable quarterly for 12 years from the date of the installation. This arrangement is thought to be the best for the taxpayers, as the charge is borne by the existing ratepayers, although it is advanced in favour of the use of the Livet system that it must be a source of great profit to any vestry or corporation."

The estimates therefore are: (1) Horsfall, £2,273; (2) Municipal Appliances Company, £4,086; (2A) ditto baths scheme, £4,895; (3) Manlove and Alliott, £2,937; (4) Livet, £1,200.

Scheme No. 1.—In this form, however, the estimates cannot be compared, as they are not all for the same work. In No. 1, for instance, the foundations are only taken as 18in. deep, and no paving is provided for. The paving would cost about £350, extra foundations £100, foundations for chimney £100, making a total of £2,283 for three cells and a chimney 60ft. in height.

Scheme No. 2.—In No. 2 the cost will be £4,086 for four cells, a chimney 150ft. high, and boundary walls. This looks considerably more expensive than No. 1, but when allowance is made for the extra cell, the boundary walls and the extra height of the chimney, the estimate is not greatly in excess of No. 1.

Scheme No. 2A.—In No. 2A, a scheme suitable for adoption by the Vestry in conjunction with the Baths Commissioners, the cost will be £4,895 for four cells (half sunk) and a chimney 150ft. high.

Scheme No. 3.—In No. 3 the cost will be £2,937 for two cells and chimney 120ft. high, but with paving £350, and foundations £100, the chimney foundations £100. the cost would be £3,487, and if another cell were added at a cost of £500, the total will be £3,987.

Scheme No. 4.—As regards No. 4, the Livet system, I do not think that the scheme proposed can meet with the approval of the Vestry. In the first place, it is proposed to screen the refuse, and secondly, the suggestion is made that the Vestry should pay a royalty of 9d. per ton for 12 years. Under certain conditions screening the refuse may be desirable, but the annual payment of a royalty is most undesirable. After all the statements made as to this system, I can only describe their offer as most disappointing.

Cost of Schemes.—It will thus be seen that the costs will be: No. 1. £2,823 for three cells, 60ft. chimney. No. 2. £4,086 for four cells, 150ft. chimney and boundary walls. No. 2A. £4,895 for four cells, 150ft. chimney, to be adapted to heat baths. No. 3. £3,987 for three cells, 120ft. chimney, and cremators.

Cost, Working and Maintenance.—The cost of working and maintenance is, of course, an important matter. We would probably require three shifts of eight hours and one man for the yard during the day, which would amount to £6 per week, or £312 per year. The cost of removal of clinkers, etc., allowing a residue of 33 per cent., say, one-third on 5,000 tons per year = 1,666 tons barged away at, say, 2s. 8d. per ton, will be £222 per year. If the cost of a four-cell destructor and chimney, 150ft. high, is estimated at £4,000, the interest on the capital at 3½ per cent. would amount to £140 per annum, and if repairs, depreciation, rates, taxes, and gas are estimated at only 10 per cent., they would amount to £400. The annual cost therefore would be: labour, £312; clinker removal, £222; interest and repayment of capital, £281; repairs, depreciation, rates, etc., £400; total, £1,215.

The present price of barging away 5,000 tons amounts to £791. It is therefore apparent that to erect a destructor without utilising the heat would mean an extra expense.

The question of the purpose to which the heat obtained could be put and the saving caused thereby must now be considered. Two purposes have been suggested—first, baths; secondly, electric lighting.

If 5,000 tons are collected during the year, it means about 13¾ tons per day for everyone of the 365 days in the year, and every ton will evaporate not less than 40lb. of water per hour for 24 hours; thus every ton of refuse will give 2 h.p. for 24 hours. I have no knowledge as to what amount of steam may be required at the Kensal Town Baths (if baths are built), but according to Messrs. Horsfall's guarantee, 1lb. of water is evaporated, from 60deg. F. to steam at 80lb. pressure per square inch, by 2½lb. of refuse, in addition to the steam used for steam jets, boiler feed, pumps, etc. (Note.—1lb. of good coal will evaporate 10lb. of water.)

As regards utilising the heat for electric lighting, there are many considerations to be borne in mind. In Kensal Town there are slightly over 200 lamps scattered over

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seven miles of streets. To lay down cables in seven miles of streets for street-lighting only (supposing that there was sufficient power in the destructor to light the lamps) would be an exceedingly costly proceeding, and the amount of energy wasted in overcoming the resistance of the conductors alone would be enormous, especially when it is taken into consideration that the amount of electricity required for the 200 lamps (16 c.p.) at 100 volts would only be about 100 amperes. In fact, to think of lighting the street lamps in the whole of the district from the heat generated in the destructor under present conditions is quite out of the question, apart from the legal objections. It therefore remains to be seen what portion of the district, if any, could be lighted, provided that the heat is not required for the baths.

Before the Vestry could break up the streets to lay mains for electric lighting it would be necessary to obtain a provisional order from the Board of Trade, and if an order were applied for the Vestry would be required to supply electricity to private houses within a certain area, and a constant supply within that area would have to be maintained under somewhat stringent provisions. Although the demand for private lighting in this neighbourhood would probably be very small, yet the obligation to provide a constant supply of electricity at a constant pressure, with the limited power which would be available if such a small destructor were the only source of power, is one of such a serious nature that it would not in my opinion be wise for the Vestry to undertake it.

If the average horse-power available is only about 26 for 24 hours, there are, of course, many days when less would be available. Suppose that 20 h.p. were only available for 24 hours, and that half the time batteries were being charged. Then we would lose 7 per cent. in the dynamos, and 20 to 25 per cent. in the batteries, or a loss of nearly 5 h.p., without taking into consideration the losses in mains. But as 15 h.p. will only light about 150 c.p. incandescent lamps, it seems hardly worth the trouble and expense obtaining a provisional order to do this, especially as the destructor buildings and vestry offices would require almost half this number.

As statements have lately been circulated to the effect that London could be "lit with electric light for nothing," and as the idea is prevalent that any town can be lighted by its dustbin refuse, it may be as well here to mention that in a paper read before the Society of Arts last February Prof. Robinson stated the cost of a unit sold, with repayment of capital and maintenance, amounted at St. Pancras to 5·18d., and that the cost of coal per unit sold amounted to 1·21d., and this price he thought was excessive. The saving by using dust will not be the 3·97d. per unit, which is the difference between the cost of coal and the total cost of a unit. For if we take Messrs. Horsfall's guarantee that one ton of refuse will give 1 h.p. for 48 hours, and suppose that we will have no losses of any sort (an ideal state of things), the ton of refuse will give us about 35 units, so that 64lb. of refuse will give us one unit, or will be equivalent to 8lb. of coal. The cost of coal will be ·760d., while the cost of barging away the 64lb. of refuse would be 1·086d., making a total of 1·846d. But this is not all gain, because 21lb. of the refuse would have to be removed as clinker, and would cost about ·317d., so that the apparent gain would only be 1·529d. per unit. And if the cost per unit sold is 5·18d., there is a difference of 3·651d. per unit. Thus in this case electricity "for nothing" means at a cost of more than 3½d. per unit, even in such an ideal state of things as I have supposed, where I have taken the cost of coal at per unit sold, and the refuse efficiency per unit generated, whereas between the two there is a great gulf in the shape of losses in dynamos, in batteries, and in mains, which would sink any company that were to calculate their price for electricity without taking it into consideration. It is also certain that the cost of working and maintenance of the destructor plant would be in excess of that of the ordinary engines. I am, therefore, of opinion that the cry of "London lit for nothing" is a trifle delusive at the present time, for if the Livet furnace will increase the evaporative power of house refuse, I can see no reason why it should not increase the evaporative power of good coal in like proportion, and enable electricians to realise their ideal of 2½lb. of coal per unit generated.

So far as the schemes now before the Vestry are concerned, if it is thought advisable to erect a destructor on sanitary grounds, and to utilise the heat for the baths—and this seems to me to be the best means of utilising it—I would suggest that scheme No. 2A, that of the Municipal Appliances Company, be adopted, as this scheme has been worked out for the Baths Commissioners, and is, therefore, I presume, suitable for their purposes, but no doubt some arrangement would have to be made to provide a supply of very inferior coal to be used when sufficient dust was not available. The scheme would cost £4,895, but as this is more costly than one suitable for the Vestry's requirements, the whole cost ought not to fall upon the Vestry, unless the extra cost be taken as an equivalent to the site which is handed over.

If, however, the Vestry desire to erect a destructor, and utilise the heat for lighting the offices and destructor buildings, and any lamps around the premises which might be lighted without a provisional order, I would suggest scheme No. 1, with the addition of a chimney 120ft. high.

Before deciding upon the actual scheme, however, the Vestry should decide whether the time has yet come when a dust destructor at Kensal Town will be advantageous. The present cost of barging dust will amount to about £800 per annum.

Since writing the above report, I have received from the Municipal Appliances Company a plan showing the application of the "Thwaite" boilers to their refuse furnace. The letter states that each furnace complete with a steam generator would cost £500, provided that at least three were ordered. The special feature in these boilers is that they are fixed on top of the destructor, and no doubt are the very best type to generate heat, though whether they are the best type to destroy foul gases is not so obvious, for at Birmingham boilers form the top of the furnace, but while giving excellent results as to evaporation of water, Prof. Forbes says of them: "It was necessary there to keep up steam for the treatment of the excreta, and steam was got up from these furnaces by putting the boilers directly over the furnace. In consequence of this, the combustion is very imperfect. The large cooling surface of the boilers impedes the combustion in an effectual degree." I cannot, of course, say that the same result will happen with these boilers, but I think that the tendency in some quarters is to sacrifice efficiency in cremation of gases to record breaking in steam production, and this in a destructor which has been called into existence primarily to cremate is a mistake.

THE COST OF ELECTRICAL ENERGY.

We give below Mr. Crompton's reply to the discussion on his paper, before the Institution of Electrical Engineers, on the "Cost of Electrical Energy."

Mr. R. E. Crompton said: I shall be obliged to reply very briefly, but hope to be allowed to answer the respective speakers more fully in the *Proceedings*. I have first to thank Mr. Raworth for his very cordial appreciation of my paper. I assure him that I had not the gentlemen named by him in my mind when writing the paper, but rather the gentlemen who are always advocating the Lancashire boiler and the long-stroke horizontal type of mill engine as the perfect type of plant for us electrical engineers to adopt for our supply stations. As Mr. Raworth was the first to take up my point on the use of Lancashire boilers, and so many others have spoken on this subject, I must point out that in my paper I have admitted that these boilers even without economisers do give excellent results on test trials, but the accounts I am dealing with show that the Lancashire boilers in actual use for electric lighting purposes have yielded a high evaporative efficiency. I believe the cause of this to be that these boilers fall off rapidly in efficiency when the firing rate is raised above 20lb. of coal per square foot of grate surface, and under the condition of electric lighting supply such a rate of firing must often be exceeded for the periods of maximum load. My figures show that the same difficulties do not exist with the multitubular boilers, either with the locomotive, marine, semi-marine, or the Babcock and Wilcox type.

Mr. Halpin asked me whether the forced rate of firing which I mentioned in relation to Babcock and Wilcox boilers was not, after all, a very low rate. I think I can satisfy him in this when I say

* *Electrical Engineer*, vol. x., p. 435.

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that the boilers I had in my mind occupy a space of about 16ft. long by 12ft. high by 9ft. wide, and at this forced rate they evaporate water enough to supply 600 h.p. indicated in the Willans engines. I do not know another boiler occupying this space which can stand this rate of firing and yet work with fair economy.

Time prevents me from replying at length to General Webber's remarks. I may say at once that most of his remarks and the arguments on them are based on erroneous information. I can, however, point out this evening that he has accused me of under-estimating the capital cost of my ideal station, whereas in his own paper describing the works of the City of London Company he estimates the capital cost of the works will be £75 per kilowatt. Mr. Geipel, later in the evening, named an even lower figure, whereas I have allowed in the present instance the very liberal figure of £100 per kilowatt of maximum load. This is a specimen of the careless way in which General Webber has read my paper.

With regard to his personal remarks, I do not think it dignified for me to make a reply to them.

Mr. Robinson and others who have spoken this evening, have stated that my ideal figures of works economy are pitched too high. I may possibly be wrong in this respect. I wished them to be difficult of attainment, and therefore pitched them high.

For Mr. de Segundo's information, I may point out that Prof. Kennedy has stated this evening that 4½lb. per unit sold to the customers is actually reached every day in some of our best stations, and I myself have seen on a six hours' trial the figure reached of 3½lb. per unit sold. If these figures have been already reached, and as we know that there are still many preventible losses, it is reasonable to suppose that we shall pretty easily reach with improved plant 3½lb.; but I admit anything in excess of this will be very difficult to attain, but this is no reason why I should not put 2½lb. as our ultimate goal, or as the 100 per cent. with which to compare our eventual economic efficiency.

I hope Mr. Schonheyder will not think that I intended to find fault with his water-meter when I stated that it is wise to frequently recalibrate it. On the contrary, I find his meter the best for this particular purpose of any that I have tried, and the necessity of frequent calibration arises from the very difficult conditions under which such a water-meter has to work.

I have to thank Mr. Hammond for his appreciation of the objects of my paper. He himself has done such good service in preparing and publishing statistics that he of all men can appreciate the difficulty there is in collecting these statistics.

I may say at once that I have met with uniform courtesy from everyone to whom I applied for information for this paper, the only case in which I was refused information being the company to which General Webber is responsible.

Mr. McLaren's remarks interested me because I know that he is a builder of record engines, and I was exceptionally pleased to hear that he was the builder of the engines which have shown such good results at Oxford.

Mr. McLean will, I hope, understand that I never intended to throw any doubt on the Oxford figures when I stated that they were almost too good to be true. Mr. McLean has gone the right way to obtain such figures—*i.e.*, by carefully measuring his losses and preparing his tables of statistics. This is the text on which I have endeavoured to preach to this Institution for the last six years.

I welcome Mr. Burnett's remarks, as I know him to be a boiler-maker of exceptionally high standing, and who has given more thought to the question of boiler economy than most people.

Returning to my ideal figures, I must point out to Mr. de Segundo that Messrs. Sultzer and other continental makers have been getting a consumption of 12½lb. of water per indicated horse-power for some years past, and I fully expect to hear that they have reached this figure in electric lighting stations in which these engines are used. It may be interesting to Mr. de Segundo to know that Messrs. Willans and Robinson are now giving guarantees with their condensing engines that the consumption will not exceed 13½lb. of water per indicated horse-power per hour.

The remarks of Mr. Shoolbred and other gentlemen who followed him on the subject as to the advantages of using accumulator storage in electric supply works are very apposite. This is a theme upon which I have often harped, and I am glad to find that I am so strongly supported. It is well known that the saving in wages from the use of accumulators is very considerable in the smaller classes of station, and even in the largest class—namely, the large central stations in New York—I am glad to say that Mr. Howell has been able to prove to the New York engineers that since he supplied accumulators to them their stations have been worked more economically—there has been a saving in fuel, and a large saving in the labour bill.

I must apologise to Mr. Dykes for the mistake in the efficiency of the Preston works. The correction was received, but was omitted to be made. Table No. VI. was corrected six or seven times, and it is small wonder that more mistakes have not occurred. The mistakes, however, only affect the B.T.U. per unit generated, and not per unit sold. I had no desire to animadvert on the accounts of this station; in fact, I hoped that someone would explain away what appeared to be such a large consumption of fuel, and I am glad that Mr. Dykes has been able to do this.

Prof. Unwin's remarks were very instructive. Although, as I have already said, I do not think that anything he has urged in regard to the Lancashire or Cornish boilers has any considerable bearing on their advantages for electric lighting stations, yet what is said about superheating is of the very highest importance, and is very encouraging to us; as I am sure after what he has said that we shall be able to adopt some form of superheater in most cases.

I am glad to note Mr. Peach's remarks as to the peculiarities and advantages of Mr. Paxman's Economic boiler. I can corroborate these remarks from personal experience.

Prof. Kennedy has given us very valuable information of the kind which I most appreciate—*i.e.*, his remarks greatly increase the value of my paper to those who may wish to use it as a work of reference. One of the important points raised by him is that he thinks that we cease to get any further advantages in reducing works cost so soon as our station is of a size to deliver 3,000 h.p. to 4,000 h.p. as a maximum load. I have for some years past required corroborative testimony on this point. I myself think that the limit of economical working is reached at an even smaller figure—say, 2,000 h p. In the old controversy as to the comparative advantages of several central stations *versus* one large external station, it has apparently not occurred to those who are always urging that our present system is wrong, that there is no appreciable advantage gained in increasing the size of a works above a certain figure. This figure I put at 2,000 h.p.; Prof. Kennedy puts it at 3,000 h p. to 4,000 h.p. If we are right, then the sole advantage of concentrating the works into one station and taking it outside the town really amounts to the saving in the cost of cartage of fuel, which advantage I believe to be very small.

This leads me to the question of the use of liquid fuel. Several speakers have thrown a doubt on the possibility of this being done successfully. I myself hold the other opinion. I think that even with very big stations if liquid fuel can be used for the stand by boilers, it will show a large economy over the use of coal for the same purpose, particularly when these stand-by boilers are only wanted for an hour or two in the course of each day's work. Several companies, including those with which I am closely connected, are experimenting in this direction, and I hope, when another paper is read on this subject, that I shall have some definite results to put before you. It does appear to me that if we can get up steam in a boiler at 20 minutes' notice, as can be done by the use of liquid fuel, we are approaching the ideal state of things as regards the boiler economy of an electric works. Further than this, I believe that as the ultimate capacity of all existing London works is limited by their room for putting in boilers, that the use of liquid fuel may increase the possible output of these stations 50 per cent.

I have now run rapidly through the criticisms which have been passed on my paper, and I must apologise to those gentlemen whose remarks, spoken or communicated, I have not been able to deal with this evening. I can only thank you heartily for the honour you have done me in taking such interest in the paper, and which has repaid me in every way for my trouble. I must repeat that my principal object in writing it was to elicit from those who work in these stations their real opinion as to the comparative advantages and disadvantages of the various types of the plant now in use. I think we have reason to be satisfied with the progress which has been made in boiler, engine, dynamo, and distribution economy, which may be summarised in Prof. Kennedy's statement that in a good station we now only use 4½lb. of Welsh coal per unit sold to the customers. We have only arrived at this point after nearly eight years of patiently studying the questions, by continuously measuring the losses and by tabulating these, and it is gratifying to record this improved result.

LIQUID FUEL.

In connection with Mr. Crompton's recent paper on the "Cost of Electric Energy," and the remarks made therein and during the discussion concerning the use of liquid fuel, the following abstract of a paper on "Liquid Fuel," read last week by Mr. G. Stockfleth before the Society of Arts, should be of interest.

The use of liquid fuel is by no means of recent date: it has for many years been pretty general in Russia, and the question cannot any more be considered as a problem which has to pass through its experimental stages. Before going further into the subject, it may be well to define which liquids can best be used as fuel. A good many oils might enter the list were it not for some indispensable requirements such as cheapness, absence of danger, capability for developing heat and undergoing complete combustion, without producing unpleasant smells, smoke, and dangerous and unhealthy gases, which conditions practically reduce the number to the oils derived from coal and from crude petroleum. The first named (oil derived from coal) is, however, not produced in sufficient quantities for even a limited consumption, and would be far too expensive to manufacture solely for fuel purposes. It is, therefore, to crude petroleum that we must turn for obtaining a suitable oil.

Crude petroleum consists almost entirely of a mixture of a great number of hydro-carbons differing in boiling point and density, and by being submitted to distillation, it gives a series of hydro-carbons known as gasoline, benzolene, kerosene, etc. It is not necessary here to give a detailed description of these different products; suffice it to say that the first distillate of crude petroleum, which evaporates at a low temperature, is the most inflammable, and gradually, as the temperature is raised, the less dangerous oils are distilled, until the temperature in the stills reaches 300deg. C. to 320deg. C.; at this point the distillate is called kerosene, and the residue (which in Russian is called astatki) forms the oil which so admirably answers the conditions for a good liquid fuel. It contains all the heavy hydro-carbons capable of creating heat, and the high temperature to which it has been exposed having freed it from all dangerous volatile liquids, guarantees its complete safety; a match or any other naked light

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is immediately extinguished when plunged into it. In order to make it burn it requires special treatment, about which more shall be said presently. The Russian crude petroleum gives about 35 per cent. benzoline, gasoline, and kerosene; the remaining 65 per cent. is used for the manufacture of lubricating oils, and mostly as fuel. To give an idea of the extent to which it is used in Russia for locomotive, steamship, and even stationary boilers, it may be mentioned that the transport of astatki from Baku to the Caspian seaports and Astrakan amounted in 1892 to 107,361,435 poods, equal to about 3,000,000 tons; and, in addition to this, some 250,000 tons were shipped from Batoum. The statistics for 1893 are not yet available for reference, but will probably show an increase. In the above-mentioned tonnage the consumption in Baku, which amounts to more than 100,000 tons yearly, is not included. Astatki is the only fuel used at the boring of the wells, and for all distilling purposes, in some cases even for domestic use in warming and cooking stoves.

For boiler and distilling purposes it is necessary to create a larger and more powerful flame, and steam is used for forming it into a spray which is easily ignited, and then burns fiercely. Many injectors or pulverisators in Russia—called fasunkas—have been constructed and patented, but it has been found that the most primitively constructed pulverisators answer as well as the more complicated kinds. The apparatus used under the stills consists simply of two ¼in. pipes—one leading the oil from a tank, the other steam from a boiler. The ends of the pipes are flattened by a blow of a hammer, and then tied together with a piece of wire: the steam jet catches the outflowing oil and forms the spray. It is well to keep the oil a little warm to facilitate its passage in the pipes through which it descends by gravitation. This pulverisator gives entire satisfaction; the flame is powerful and bright, and not a drop of oil is wasted when once the flow has been regulated. No smoke or flame ascends the chimney—which, by the way, can be very short—as the steam jet itself creates sufficient draught. A somewhat neater appearance can be given to the injector when the oil-pipe is arranged inside the steam-pipe, and provided with a cast-iron or brass nozzle which can be shaped to give the flame any desired form.

Experiments have been made with compressed air for spraying the oil, but the results have not materially differed from those obtained with steam. Air must, of course, in any case have access to the flame, and openings on the front of the flue must be provided for its admittance. In most cases the hole in the furnace door through which the nozzle of the pulverisator is introduced, is sufficient for letting in the quantity necessary for the combustion. The action of the steam is therefore solely mechanical, and serves only for cutting up the oil in small particles, which, being surrounded by the necessary air for their combustion, catch fire before they reach the bottom of the flue. By using steam for spraying no oil accumulates in the flue when the flow is regulated, consequently a complete combustion of the oil takes place. If better results should be obtainable by using compressed air for spraying, the reason would have to be looked for in some chemical effect of the steam upon the oil, which to some extent could deprive the latter of its heat-creating properties. There is, however, no probability for this anticipation; if the steam had this effect it would already have done its work in the still, where superheated steam is admitted into the crude oil to facilitate the distillation of the different crude oil products. Looking at the question from the point of cost, it is not probable that the compressed air can be produced cheaper than the necessary quantity of steam taken direct from the boiler. It is, in fact, but a very small quantity which is necessary for doing this work when the pulverisator is properly constructed; and no case has come to my knowledge in Russia where the adoption of liquid fuel has augmented the quantities of feed-water used in a perceptible degree. The chief point in the construction of the pulverisator is to avoid waste of steam; that is to say, to construct the nozzle in such manner that every particle of steam takes care of a corresponding particle of oil. This object will best be secured when the openings for the steam, as well as for the oil, are made long and narrow, and are placed as close to one another as possible. All the different Russian constructions are made in this way. The openings are about 1¼in. long, and ¼in. to ⅛in. wide. As the oil sometimes contains paraffin, which is likely to choke this narrow opening, it is essential to have an arrangement by which steam can be led through the oil-passage to clean it out. The rest of the construction may be varied to suit particular cases, and with a view to facilitate and cheapen the manufacture. At the present time a great many ships on the Black Sea, and all steamers on the Caspian Sea, as well as all locomotives in Southern Russia, burn astatki.

The last years have seen a complete revolution in boiler-making. Water-tube boilers seem to be the type of boiler for the future. Various constructions are in the market, and a keen competition is going on for the best designs. Without going into details, it may be mentioned that the principal merits claimed are reduction of size and rapidity in raising steam of high pressure. Oil-firing greatly furthers these ends; fire-grate and ashpit can be done away with altogether, the length of the funnel can be reduced, and a system of water-tubes is better suited to the fierce fire of liquid fuel than the straight or curved surface of an ordinary thick boiler-plate. No boiler specially designed for liquid fuel is yet in the market, but the subject leaves certainly a wide field open for the boiler designer who, with liquid fuel, can obtain a flame which can be controlled, directed, and give uniformity much better than a coal fire, and which is less dependent upon air currents.

A disposition to use liquid fuel has already been shown in this country, both for locomotives and steamships. A certain number of locomotives, and even stationary boilers, have been fitted to use oil, and have burnt the tar oil which was obtainable. A small quantity also of astatki which had been shipped to this country has been employed for steamship use.

TELEGRAPHY, PAST AND PRESENT.

Before the Balloon Society on Tuesday, Mr. Charlton Wollaston, C.E., delivered an address on the above subject, Mr. W. H. le Fevre (president) occupying the chair. The President, in introducing the lecturer, mentioned that Mr. Wollaston laid the first telegraph cable between Dover and Cape Grisnez, under the concessions granted to the Bretts; that he was engineer at the introduction of the Cape and Natal land telegraphs; and that he continued the management of the former until they were taken over by the Colonial Government. Mr. Wollaston was one of the early practical developers of the Gower-Bell, or loud-sounding telephone, which was adopted by the General Post Office.

The lecturer first traced the early history of telegraphy from the year 1747, and referred to the various workers in this branch. Dealing with 1845, he described the first submarine telegraph—viz., that from Dover to France. The concession was granted in 1847, but the revolution of that time placed the Provisional Government into the hands of Lamartine, and later into the hands of Louis Napoleon, afterwards Emperor. By each of these the concession given to the Bretts was confirmed (by Napoleon, in 1849, who extended the time), but no one would take up the scheme, and no one believed in it. Nevertheless, the first cable was put in hand in 1850. On August 28, 1850, one end of the new cable was attached to a pile of the Admiralty Pier at Dover, and the adventurous expedition started. On the following day the *Times* announced that communication had been established to Cape Grisnez.

The jest of yesterday had become the fact of to-day, and now telegraph cables thousands of miles long encircled and crossed the world. The earlier part of this century was one of surpassing interest in the advance of electrical knowledge, and all the requirements for an electric telegraph were at hand—viz., the voltaic battery, the electromagnet, the multiplying coil, the magnetic needle, together with the knowledge that a suspended magnetic needle could be deflected by a galvanic current passing through a fixed coil adjacent to it. The lecturer said that it was not to be wondered at that numerous devices for carrying on the telegraphic communication by means of electricity were proposed and shown by many philosophers and experimentalists in different parts of the civilised world, and that its present extension and usefulness should command and regulate the commerce and destinies of nations.

SPECIAL REPORT ON THE HERMITE SYSTEM OF SEWAGE TREATMENT.

Since the issue of Dr. Kelly's report on the Hermite system at Worthing, and which was published in this journal at the time, we have reproduced the conclusions arrived at by Dr. Piton in regard to the experiments made with this method of sewage treatment at Brest. We now make no apology in giving a few extracts from the lengthy report prepared by the *Lancet* special analytical commission appointed to deal with the experimental plant at Worthing and with the system in the laboratory. After describing the plant at Worthing, the report goes on to deal with experiments relating to the chemical and bacteriological examination of the electrolysed fluid at varying strengths, and of the treated sewage effluents, and to the behaviour, chemical and bacteriological, of certain compounds of similar chemical composition:

We have shown in the foregoing results that electrolysed sea-water contains probably as its chief active constituent hypochlorous acid, resulting from the partial dissociation of magnesium hypochlorite, and that it is fairly stable under ordinary circumstances; that it is a powerful bleaching liquid, being superior in this respect to bleaching powder solution, but not to a solution of bleaching powder of equal chlorine value, in which the hypochlorous acid has been liberated by the addition of a weak acid (CO_2 or others, in weak solution); that it is also a powerful deodoriser; and that in all probability these properties are due to the united action of oxygen *in statu nascendi* and chlorine. These, in brief, are the chemical properties of electrolysed sea-water, and it remains for us to consider what effect for good or for evil such a liquid of definite strength would have when mixed in a certain proportion with fæcal matter. It deodorises, but does not destroy nor remove, organic matters, although there is little doubt that certain of them are partially changed, and most probably those which are more readily putrescible. While these things are true and so far satisfactory, there must also be certain drawbacks in the system which are likewise indicated in these experiments. Electrolysed sea-water, for instance, is rapidly reduced in strength by common newspaper, and as this is an almost invariable accompaniment of human dejecta its presence in the sewer must seriously affect the activity of the liquid, even if it does not withdraw the active constituent entirely. Indeed, the entire contents of a sewer rapidly appropriate the chlorine strength of the liquid. The same observation applies to the soap or domestic waste, etc., which rapidly "kills" oxygenated

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chlorine compounds. Again, it can only be supposed that deodorisation, not to say sterilisation, is complete when the chlorinated body is in excess, and an effluent containing free chlorine or its equivalent is inadmissible to rivers. The expense, moreover, in inland towns would be greater, since it would be necessary either to carry sea-water or to prepare it artificially. M. Hermite's proposal is to establish a producing centre in the towns and to supply the liquid through pipes into all the streets and houses much in the same way that water and gas are at present supplied. The adoption of such a scheme in any place would no doubt lead to a sanitary condition of things hitherto unreached, but many excellent advances could be made in the same direction, it should be remarked, if cost were not an item which so often bars the way. Apart, however, from such a scheme, there is no doubt that the production from sea-water of a powerful bleaching agent and deodorant is an innovation which should afford very material aid to sanitary progress. Thus, for many purposes, the substitution of electrolysed sea-water for other and more expensive agents in our seaside towns and villages would doubtless confer many advantages. It could be used, for example—with desirable effect, doubtless—to flush the headings of drains and sewers; it could be discharged into sewage outfalls; and, lastly, the system could be applied on a small scale for the sanitary treatment of hospitals, barracks, etc., by means of an automatic electrolyser worked from a central electric supply. It should be added that except as regards what has already been published in our columns, no particulars in regard to the actual cost of production have as yet been furnished by the originator of the main idea.

Antiseptic Action of Hermite Solution diluted with Distilled Water.

TYPHOID.

Available gramme of chlorine present per litre.	Immediate.	Five minutes.	Ten minutes.	Fifteen minutes.	Thirty minutes.	One hour.	Twenty-four h're.	The original dilutions of Hermite fluid were re-inoculated with B. typhosus on the fifth day, and after standing 24 hours were tested by inoculations into broth.
0·60	+	—	—	—	...	..	...	...
0·30	+	—	—	—	...	...	...	...
0·30	...	—	...	...	...	...	—	+
0·20	+	—	—	—	...	...	...	...
0·17	+	+	—	—	—	...	...	...
0·15	+	+	+	+	...	...	...	...
0·15	...	+	...	+	...	...	—	+
0·13	+	+	...	...	...	...	...	...
0·12	+	+	+	+	...	...	...	...
0·10	..	+	...	...	+	+	—	+
0·05	...	+	...	...	+	+	+	+

The question now comes to be: are we correct in assessing the antiseptic value of the Hermite solution in terms of available chlorine, as in that case a solution of chlorine water of equivalent strength should exert a similar action? This question we have attempted to answer in the following table:

Antiseptic Action of Chlorine Water.

TYPHOID.

Gramme of available chlorine present per litre.	Five minutes.	Twenty-four hours.	The original dilutions reinoculated on the third day with bacillus typhosus were, after standing 30 minutes, again inoculated into broth.
0·70	—	—	—
0 35	—	—	—
0·23	—	—	+
0·14	+	—	+
0·10	+	—	+
0 05	+	—	+
0·03	+	+	+

On comparing this table with the results obtained with Hermite solution, given in the first table, it will be found that the two correspond almost exactly, or, at any rate, vary only within the limit of experimental error. Thus 0·17 and 0·05 of Hermite solution give a positive result in five minutes and 24 hours respectively where 0·14 and 0·03 of free chlorine are required to produce the same results. We are accordingly warranted in concluding that we may generally estimate the antiseptic value of the different oxychlorine compounds present in the Hermite solution in terms of their available chlorine or oxidising power, although we are unable to define to what extent the antiseptic action is due directly to the chlorine or to its indirect action as an oxidising agent. They however, no doubt vary very much as regards the readiness with which they exert this action, some being more stable than others, and it would also seem that some of them are able to form comparatively stable compounds with other substances, by means of which their antiseptic power may be retained almost indefinitely; thus we have found that samples of broth which had received comparatively small quantities of the Hermite solution, even after seven weeks contained a sufficient amount of available chlorine to be titrated in the form of iodine by means of thiosulpate of sodium. We have observed also that the effluents from Yard B, which appeared at first to continue to fall in their available chlorine, seemed after a time to remain stationary. If the antiseptic value of the fluid, then, depends merely on the available chlorine, may we not substitute a solution of bleaching powder of equivalent strength as being probably much less expensive and more easily prepared. Our experiments with typhoid cultures, however, would seem to indicate that at least half as much again of this solution is required to produce the same result in the same time, although from its greater stability it is perhaps more efficacious when allowed to act over a longer period. Our "artificial" Hermite solution, prepared by passing carbonic acid gas through the bleaching powder, gave varying results, due to some factor which for the present escapes us, and although the bleaching powder solution is rendered slightly more powerful, still it could not be depended upon to exert, constantly, an equivalent action to the Hermite solution. The influence of the carbonic acid gas is, however, brought out in a most striking fashion by our experiments on the very resistant spores of bacillus mesentericus vulgatus.

If we compare the action of the Hermite solution as an antiseptic with carbolic acid, the superior efficiency of the former is so evident, even in solutions of relatively great dilution, that we are left in no doubt as to which is to be preferred. The only substance used as an antiseptic, which operates in solutions of such great dilution, is corrosive sublimate ($HgCl_2$), and, although the laboratory experiments might appear to give it a certain advantage, we are confident that the facility with which it unites with organic bodies, and thereby becomes inert, would render it very much less efficacious than the Hermite solution for general use as a practical disinfectant. The electrolysed sea-water, or our "artificial" Hermite solution, appears, indeed, while exerting a specific disinfecting action on the organisms, at the same time to be used up and destroyed to a much less extent by the organic matter present than any other disinfectant with which we are at present acquainted.

In applying the results which we have obtained from our examination of the Hermite system carried out on the spot and our more extended laboratory experiments, it must first be stated that all investigators who have occupied themselves with the question of sterilisation of stools have found it most difficult to render them absolutely sterile in a short space of time by the ordinary means available, and have accordingly addressed themselves more to the solution of the problem of what would be sufficient to free them from the pathogenic germs, such as those of typhoid fever and cholera, which might be present. We are quite satisfied from our examination of the effluent in Yard B that all such would be effectually dealt with, as the more resistant bacterium coli commune appears to be destroyed. It is probable from a number of observations which we have made, which it is unnecessary for us here to record, that the titrations of the effluent do not really indicate fairly its antiseptic power, but that this is really much greater than the arsenious acid method would lead us to expect. It will also be noticed that the higher strengths of solution supplied from the distribution tanks do not so markedly raise the amount of available chlorine in the effluent as might be expected, and this is to be accounted for by the more unstable portion of the solution being at once converted into some other form, which, although not indicated by the arsenious acid titration, may still be effective as an antiseptic. The bacteriological results also are not improved to such an extent as to warrant us in recommending the adoption of such strong solutions of the Hermite fluid, as this would necessarily entail no inconsiderable addition to the cost involved in the adoption of the system; a system of between 0·50 and 0·60 gramme chlorine per litre is all that we should consider necessary to effect the proposed objects of this method of sewage treatment. The adoption of any mixed system in which the house water, even without the storm water, is allowed to enter the drum in which the sewage undergoes treatment must, so far as we can see at present, always be accompanied by the danger that the whole object of the scheme may be rendered futile from the fact that we must rely wholly upon the care and judgment of the inmates of the household for the addition of sufficient quantities of the antiseptics from the sink. The application of the solution for watering the streets does not, we think, require serious consideration. The question of the flushing of the drains requires, however, further investigation, as although the direct antiseptic action would probably be small, the deodorising and cleansing effects might have some value, but this can only be decided by direct experiment. The application of the system to hospitals in the complete form recommended by M. Hermite has much to be urged in its favour. The regular disinfection of all objects which have been exposed to contamination in the wards or in the side rooms by such a powerful disinfectant, which would always be at hand, must minimise the risk of the spread of infection which emanates from all such centres of disease. Its substitution in laboratories for the ordinary disinfectants now in use also follows as a natural consequence, and, inasmuch as what may be termed the "artificial" Hermite solution can be made to any strength at an insignificant cost, whilst the electrolysed sea-water can be raised to a strength of only a little over one gramme chlorine per litre, and this at an ever relatively increasing cost, it offers very obvious advantages for such purposes.

The development of the Hermite system must be regarded as merely one of the signs of a distinct movement in sanitary science which for some time has been manifesting itself in other directions. The idea of cutting off the prime etiological factor by sterilising whatever is supposed to contain the infective agent is at present the main stand-by of preventive medicine, Mr. Henman having

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quite recently even applied the idea to the prevention of the spread of infection from fever hospitals by means of a system of ventilation in which the air is subjected to processes of filtration and sterilisation before it is allowed to pass outside the infected buildings; this is also seen very clearly in the strong tendency of modern sanitation as regards cremation of cadavers. On the other hand, another system—that of Mr. Seymour Haden—appears to advance in quite an opposite direction, inasmuch as the burial of the body in as unprotected a fashion as possible is resorted to in order that the processes of putrefaction may proceed more rapidly and the organism be resolved into its component elements. In a similar way Mr. Scott Moncrieff, instead of endeavouring to "sterilise" the sewage, has introduced a system in which he proposes to facilitate the processes of putrefaction by placing the sewage under specially favourable conditions to bring about that end, so that the complex organic matter may be broken down as rapidly as possible into a series of lower compounds, which can be taken advantage of for agricultural purposes, whilst at the same time he relies upon the vigorous action of the putrefactive organisms and the conditions produced by them to destroy or render inert any pathogenic micro organisms which may happen to be present. As to which of these two methods will finally triumph, or whether they may not in the future be combined and come into common operation, it is at present somewhat difficult even to venture an opinion.

PHYSICAL SOCIETY.

At a meeting of this society on May 25th, Prof. A. W. Rücker, F.R.S., president, in the chair, **Prof. W. Ramsay, F.R.S.**, read a paper on "**The Passage of Hydrogen through a Palladium Septum, and the Pressure which it Produces.**" After referring to the analogy between osmotic pressure of solution and the behaviour of hydrogen and palladium, the author described the apparatus he had used in his experiment, and showed it in operation. A vertical platinum tube provided with a palladium cap is enclosed within a glass vessel through which hydrogen or other gases may be passed, and outside the glass is a vapour jacket by means of which a constant temperature can be maintained. The lower end of the platinum tube communicates through a graduated capillary tube with an adjustable manometer, which enables the volume of the enclosed gas to be kept constant. Great precautions were taken for ensuring purity and dryness of the gases used. After filling the palladium and platinum tube with dry nitrogen at atmospheric pressure and the desired temperature, hydrogen was passed through the glass vessel. Some of the hydrogen permeated the palladium walls, thus increasing the pressure inside. After some time (usually an hour or so) the pressure attained a steady value, and the total increase was then observed. Experiments were made with air, nitrogen, nitric oxide, nitrous oxide, carbon dioxide, carbon monoxide, and cyanogen in the palladium tube, and in some cases the hydrogen was diluted with nitrogen. In all cases the maximum pressure of the hydrogen within the tube was less than that of the hydrogen outside the tube, as will be seen from the following table, which shows the ratio of these pressures under various conditions:

Gas originally inside tube	Gas passed outside tube.	Temperature.	Ratio $\frac{\text{Internal hydrogen pressure}}{\text{External hydrogen pressure}}$
Nitrogen..	Hydrogen	280° C.	0·9053
,, ..	,,	335°	0·8984
,, ..	,, 50 % (rest N.)	,,	0·9362
,, ..	,, 25 ,,	,,	0 9344
Carbon dioxide ...	Hydrogen	280°	0·9621
Carbon monoxide	,,	,,	0·9545
Cyanogen.	,,	,,	0 9693

After the palladium had been used once or twice it became coated with mercury (vaporised from the manometer) and lost its permeable properties. It was found necessary to heat the tube to remove the mercury, and then dissolve off the oxide of palladium thus produced, after each experiment. The permeable nature of palladium was found to depend greatly on the temperature, for at 232deg. C. the passage of hydrogen was so slow that the internal pressure was still rising after 10 days; at 330deg. the passage was very rapid. An attempt to use the apparatus for giving a continuous indication of the amount of hydrogen in coal-gas failed because the palladium did not retain its activity sufficiently long. Other experiments showed that nickel is impervious to carbon monoxide. In the latter portion of the paper the author discusses the various "so-called" explanations which have been given of the phenomena, but finds none satisfactory. Experiments on the absorption of gases by platinum and other metals are in progress with a view to the further elucidation of the subject. **Mr. Mond** thought the fact that rise of temperature accelerates diffusion tended to confirm Graham's view that the gases pass through openings in the solid, for increase of temperature would widen any pores which might exist in the metal. The **President** enquired whether the author's argument against the possibility of palladium hydride condensing in the pores of the metal, because of its being unstable at the temperatures employed, would be affected by the fact of water being capable of existing in contact with glass at temperatures much above boiling point. In reply, **Prof. Ramsay** said the president's suggestion might be true, but if so another condition must be fulfilled—viz., that the hydrogen molecules must be split up into the atomic or nascent state.

A paper on "**The Expansion of Rarefied Gases,**" by **Prof. W. Ramsay, F.R.S.**, and **Mr. E. C. C. Baly**, was read by the latter. In the first part of the paper a historical summary of previous researches on the subject is given, and the chief sources of error pointed out. The method employed by the authors was to have two McLeod gauges connected with a pump, and arranged so that both could be trapped under exactly the same pressure. One of the gauges was surrounded by a vapour jacket at about 130deg. C., whilst the other was cold at about 13deg. C. After both were trapped, the hot gauge was allowed to cool, and the readings of both taken. From these observations the coefficient of expansion of the gas used could be calculated. The experiments also served as tests of the reliability of the McLeod gauge under different conditions. For air and carbon dioxide the gauges proved quite unreliable, whilst for hydrogen they were very satisfactory. With carbon dioxide the surface condensation was so large as to make the observations worthless, but hydrogen suffered no condensation between pressures of 650mm. and 0·000076mm. Great difficulty was experienced in filling the gauges with pure hydrogen, but when accomplished the expansion was found to be normal ($\frac{1}{273}$) down to 0·4mm. pressure, and diminished to $\frac{1}{300}$ at 0·07mm. Oxygen, however, gave a coefficient of $\frac{1}{281}$ at 5mm. pressure, $\frac{1}{316}$ at 2·5mm., and $\frac{1}{313}$ at 1·4mm. At 0·7mm. its behaviour was most erratic, there being as much as 15 times the amount of gas trapped in the gauge at one time as at another. This confirms C. Bohr's observations on the anomalous behaviour of oxygen about this pressure. For nitrogen the values of the coefficients found were $\frac{1}{310}$ at 5mm., $\frac{1}{304}$ at 1·1mm., and $\frac{1}{312}$ at 0·66mm. At small pressures the elasticities of hydrogen, nitrogen, carbon dioxide, and air increase with decrease of pressure, but in oxygen the reverse holds. Examining the consequences of this increase of elasticity in the light of the kinetic theory of gases, the authors point out that it means an increase of internal energy, and suggest that this may be the cause of phosphorescence in high vacua.

The **President** announced that the discussion on the last paper would be taken at the next meeting, after proofs had been distributed to members.

LEGAL INTELLIGENCE.

MUIRHEAD AND OTHERS v. THE COMMERCIAL CABLE COMPANY, LIMITED.

It will be remembered that in the report of this case given in our issue of May 4, it was stated that a day would be fixed for his Lordship to bear counsel's arguments upon the question as to whether or not the plaintiffs—who were the successful parties—were entitled to interest and at what rate upon the amount recovered? The question involved a very considerable sum. The learned Judge heard the arguments in his private-room early in May, and on May 11 he delivered judgment in favour of the defendants.

Mr. Justice Kennedy said: In this case there was a question, which was discussed after judgment had been given for the plaintiffs upon the main point in the case, as to whether or not the plaintiffs were not entitled to interest, and he had been referred to several decisions upon the point, the latest of which was one that was in his mind when the matter was first mentioned—viz., the London, Chatham, and Dover Railway Company *v.* the South-Eastern Railway Company. In the present case he did not think there was any difficulty in the way of the plaintiffs upon the question as to whether the amount to be paid by the licensees—the defendants to the licensors—the plaintiffs under the agreement of January 2, 1884, was a sum certain or not; therefore, in his opinion, the case referred to did not apply, for in it the decision had turned upon the question as to whether there was a debt or sum certain within the meaning of Will. IV., c. 42, section 38. But the case which was a binding authority upon him, and which was followed by the Court of Appeal in the London, Chatham, and Dover Railway Company *v.* the South-Eastern Railway Company was the Merchant Shipping Company, Limited, *v.* Armitage, and the question was whether or not—that decision of the Exchequer Chamber being binding—this agreement does or does not make the sum upon which interest is claimed a sum which is, by the terms of the agreement to be paid at a certain time? The words were, he said, "sum certain payable, by virtue of a written instrument, at a certain time." Now, as he understood the effect of that decision, and the judgment of Lord Blackburn—the dissentient judgment in the more recent case of Duncombe *v.* the Brighton and Norfolk Hotel Company—it was that it is not sufficient that the "certain time" should be a time ascertainable by calculation from the written instrument, but must be a "certain time" definitely fixed by the instrument itself without the necessity of subsequent ascertainment—in short, that it requires nothing more in order to fix the date than to look at the instrument itself. He had, therefore, to look at this agreement and see whether the time for payment was a certain time by virtue of that instrument, and, in his opinion, it was not, and therefore, on the authority of the Merchant Shipping Company *v.* Armitage he must refuse interest to the plaintiffs. His reason for

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doing so was, shortly, that article 5 (of the agreement), dealing with the question of time, fixed the royalty in these terms: "The royalty, determined as above mentioned, shall be payable in London quarterly, and shall commence to run from the expiration of the first period of 15 consecutive days during which the inventors shall have maintained their said apparatus in good working order on the company's cables or cable, and after a realisation of an increase of 30 per cent. at least in the power of transmission of the cables shall have been determined between the parties," and then there was further provision. His Lordship said that, looking at the method of ascertainment of time as prescribed in that article, it seemed to him quite impossible to distinguish this case from the one he had referred to as decided in the Exchequer Chamber For those reasons his Lordship said he must disallow the plaintiffs' claim for interest. Judgment would therefore stand for the amount claimed, less, as he understood it, the sum of £135, which had been paid into Court and which the plaintiffs were entitled to take out.

Mr. Pollard reminded his Lordship that there was another point on the question of interest, which did not depend upon the written agreement, but upon the express claim in the writ.

Mr. Justice Kennedy said that upon that point he was quite clear that the fact of there being a claim and demand in a writ was not a demand within the operation of the section (3 and 4 Will. IV., c. 42, s. 28), which constitutes a demand. He was, therefore, against him on that point as well.

Mr. Pollard argued the question of interest on the plaintiffs' behalf; and Mr. Walter appeared for the defendants.—*The Times.*

BUSINESS NOTES.

Western and Brazilian Telegraph Company.—For the past week the receipts were £2,287.

Liverpool Overhead Railway.—The traffic receipts of this railway for the week ended 27th ult. amounted to £874.

Brazilian Submarine Telegraph Company.—An interim dividend of 3s. per share for the quarter ended March 31 is announced, payable on June 22.

Plymouth.—Messrs. Hearder and Son, of Plymouth, have been chosen to fix one of their improved lightning conductors to the new church at Budleigh Salterton.

Change of Address.—The rapid extension of their business has necessitated Messrs. Bennett and Druce to remove to larger and more convenient offices at 30, Winckley-square, Preston.

Bristol.—The Electrical Committee of the Town Council met at the Council-house on Friday, Mr. Charles Wills in the chair. The committee decided to meet once a month only during the summer months.

Shoreditch.—The Vestry have affixed their seal to the contract for the purchase of the Pitfield-street site, for the erection of a dust destructor, baths, library, and electric lighting station, at an estimated cost of £100,000.

Sheffield.—The Electric Light and Power Company commenced on Monday the work of laying underground mains westward, and it is expected that the current will be available to consumers during the ensuing autumn.

Claybury Asylum.—On Wednesday, Mr. Ross Cotton, A.I.E.E., was presented by the electric lighting staff with a silver-mounted walking-stick, a cigar-case, and an illuminated address on the occasion of his leaving the above station.

Exeter.—The Devon Standing Joint Committee have accepted the offer of the Exeter Electric Light Company to instal the electric light at the central police station for £55, and to supply current at an annual estimated cost of £39.

Portsmouth.—Seven tenders have been received by the Portsea Guardians for providing and fixing electric fittings to the Guardians' office in St. Michael's-road. Messrs. Walker and Co., of Queen-street, Portsea, quoted the lowest price, £67, which has been accepted.

An Electrician Required.—A practical working electrician is required to take charge of an installation of about 2,000 incandescent and 50 arc lamps. Applications are to be made by letter to No. B 22, *Electrical Engineer* Office, 139-140, Salisbury-court, London, E.C.

Tenders for Acton.—The Acton Local Board invite tenders by the 5th inst. for the transfer of the provisional order obtained by them, and for the installation of electric lamps in the streets. Further particulars may be obtained at the office of Mr. D. J. Ebbetts, surveyor.

Tenders for Coventry.—The Town Council invite tenders for the erection of an electric lighting station. Plans and specifications may be seen on application to Messrs. George and Isaac Steane, 22, Little Park-street, Coventry. Tenders must be delivered by the 13th inst.

Yeadon.—The Board of Trade Provisional Order Bill, authorising the Yeadon Local Board to make electricity, and to supply the current through mains to consumers by meter, passed the Examiner in the House of Lords on Standing Orders on Tuesday, and was ordered to be reported for second reading.

City and South London Railway.—The receipts of the Company for the week ended May 27 were £931, against £844 for the same period last year, or an increase of £87. The total receipts for the first half-year of 1894 show an increase of £564 compared with those for the corresponding period of 1893.

Fleetwood.—The clerk mentioned to the Improvement Commissioners at the last meeting that tenders for the electric light station, etc., were about being received. The 26th of May was named as the last period for recognising tenders.

Hanley.—The local authorities at Hanley are proceeding slowly towards completing the arrangements for the public lighting of the town by electricity. The light is being used in shops and in the free library, and will soon be available for use in the other public buildings and the streets. The street lamps have been tested.

Ship-Lighting.—The s.s "Maria Herrara," built by Messrs. David J. Dunlop and Co., Inch Works, Port Glasgow, for a Havana firm, has been fitted throughout by Messrs. Claud Hamilton and Co., Limited, with the electric light, including the masthead and side-lights, as well as a powerful portable light for working the cargo.

Tenders for Alford (Lincs.).—The Inspectors for Lighting the Town of Alford are prepared to enter into a contract for lighting the town with gas or other light from August 14 to May 14, 1895. Tenders will be received up to June 9 at the office of the Inspectors, West-street, where all particulars may be obtained. Mr. W. E. Rushton is the clerk.

Norwich.—In connection with a discussion on the subject of the public gas lighting of the town, Mr. Wild, one of the members of the Town Council, stated at a recent meeting that the experiments in the use of the electric light in St. Andrew's Hall during 25 organ recitals had resulted in a saving of from 20 to 25 per cent. as compared with gas.

Tenders for Grimsby.—Tenders are invited by the Grimsby Urban Sanitary Authority for the lighting of the public streets of the borough for a term of one year. Forms of tender, copy of specification, and any further information, may be obtained on application to Mr. Marshall Petree, borough surveyor, Town Hall. Tenders are to be delivered at the town clerk's offices, West St. Mary's-gate, by June 8.

Salisbury.—In our last issue reference was made to the negotiations proceeding between the Town Council and Mr. W. H. Gramshaw on the subject of electric lighting. The Town Council have now unanimously assented, on the request of Mr. Gramshaw, to an application by the Salisbury Electric Light and Supply Company, Limited, to the Board of Trade for a license to supply the district with the electric light.

Mill-Lighting.—Messrs. Bennett and Druce, of Preston, have received instructions from Messrs. Ormrod, Hardcastle, and Co., Limited, Bolton, for the complete lighting of their mills. The plant will consist of a 78-kilowatt dynamo driven off the main engine, and about 1,250 lamps of 16 c.p. A pilot plant, consisting of a "Marshall" vertical engine and a 100-light dynamo, will also be installed to supply the lamps required during the daytime.

Telegraphic Apparatus Required.—The North-Eastern Railway Company invite tenders by the 5th inst. for the supply of the undermentioned articles in such quantities as they may require during the six months ending December 31, delivered, carriage paid, at the company's telegraph stores at York—viz., (1) telegraph apparatus, (2) telegraph wire and line stores. Forms of tender may be obtained on application to Mr. Graves, Telegraph Department, York.

Electricity Works Inspector.—The Commissioners of Sewers are about to appoint an inspector under the Electric Lighting Acts, 1882 and 1888, and the City of London Electric Lighting Provisional Orders A statement of the duties may be had on application at the office of Mr. Henry Blake, principal clerk, Sewers Office, Guildhall. The salary will be £250 per annum. Applications must be addressed to the clerk to the Commissioners of Sewers, Guildhall, E.C., and delivered by June 12.

Bridlington Quay.—The Bridlington Local Board have decided to light up the sea-front from the north end of the Prince's Parade to the north end of the Beaconsfield sea-wall by electricity, at an estimated cost of £275. The Prince's Parade has been lighted by electricity for the past three seasons, and it has proved such a success that the Board have determined to extend this mode of lighting. Seven arc lamps of 2,000 c.p. each will be used, and supplied from the Board's station on the Prince's Parade.

Belfast.—On Monday a meeting of the Electric Lighting Committee of the Town Council was held to consider the tenders for the erection of the new central electric lighting station in Chapel-lane. Seven tenders were submitted, that of Messrs. M'Laughlin and Harvey being accepted, subject to it receiving the approval of the engineer and confirmation by the Council. The committee are insisting upon all the arrangements being carried out with the utmost despatch, so that the electric light may be available by September 1.

Dundridge.—An electric light installation has been completed by Messrs. Veale and Co., Limited, of St. Austell, for Mr. Robert Harvey, of Dundridge, near Totnes. The mansion is extensive, and altogether 135 lamps, varying from 8 c.p. to 32 c.p., have been installed. The current is generated by a Crompton dynamo, driven by a Crossley oil-engine equal to 7 h.p. actual. The current is used to charge storage batteries consisting of 53 cells. The lamps have been selected with a view to the special purpose which they are to serve.

Tenders for Bedford.—As stated in our last issue, the Corporation of Bedford invite tenders for the construction, supply, and laying down of the necessary plant and mains for the supply of electricity in the borough. Specifications may be obtained from and plans may be inspected at the office of Mr. F. H. Medhurst, B.Sc., M.I.E.E., 13, Victoria-street, Westminster, S.W., on pay-

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ment of £2. 2s. per section, which will be returned on receipt of a *bonâ fide* tender. Tenders are to be delivered at the office of Mr. T. S. Porter, clerk. Town Hall, Bedford, by June 16.

Worcester.—The Watch Committee of the Town Council have resolved to recommend the Council to fix the charge for the private supply of electricity at 5d. per unit. It has also been resolved to recommend a cash discount on quarterly accounts of 5 per cent., and that the following scale of discount on annual bills should be allowed: £25 3 per cent., £50 5 per cent., and £100 and over 10 per cent. The proposal for suspending arc lamps over the roadways has been abandoned, and the Brush Company have been requested to submit designs with prices of brackets for fixing lamps on houses in the streets.

Provisional Orders.—The Lords had before them on Tuesday the Electric Lighting Provisional Orders (No. 3) Bill, the object of which is to confirm certain provisional orders made by the Board of Trade under the Electric Lighting Acts, 1882 and 1888, among them being an order empowering the Shropshire Electric Light and Power Company (Shropshire) to use electricity. Formal proof having been given, it was decided that the standing orders had been complied with, and the Bill will in due course be reported for second reading. In the case of the Electric Lighting Provisional Orders (No. 4) Bill a similar course was adopted.

A Rise in Shares.—"In the course of the past few days," says the *Financial Times* of Friday last, "there has been a demand for the securities of the City and South London Electric Railway Company, and the quotations have all advanced. The debenture stock has risen five points, to 115, the preference shares ¼, to 11¼, and the ordinary stock is three up, at 33. There is no special reason for the movement beyond the fact that the stocks are comparatively cheap. The traffics also have been showing well of late, there being a total increase for the first 19 weeks of the present year of £364 on an aggregate take of about £17,000."

Consolidated Telephone Construction Company.—The report of the Consolidated Telephone Construction Company, Limited, for the year ended March 31 states that the operations show a manufacturing profit of £3,070, and a net profit of £2,577. With the amount carried forward, a balance of £3,695 is left for disposal after making prevision for doubtful debts. The directors propose to pay a dividend of 2 per cent. for the year, to write off a further £64 from the cost of the new building, 10 per cent. from the furniture account, and £15 from goodwill, patent rights, etc., and to reserve £122 for rentals paid in advance, carrying £1,301 forward.

Chesterfield.—A similar electric lighting provisional order to that of Buxton has been introduced into the House of Commons on behalf of the Chesterfield Corporation. The area of supply is to be the area of the borough of Chesterfield. The streets to be supplied within two years of the commencement of the order are Market-place, New-square, Lower-pavement, High-street, and Packer's-row. The general powers and charges for electric light are precisely similar to those proposed to be enacted in the case of Buxton. The order, which has come before Mr. Mellor as an unopposed measure, has been ordered to be reported for third reading.

Buxton.—The Buxton electric lighting provisional order, which has come before Mr. Mellor, chairman of Ways and Means, at the House of Commons as an unopposed measure, has been granted by the Board of Trade under the Electric Lighting Acts, 1882 and 1888. The object of the order is to empower the Local Board of Buxton to manufacture and supply electricity over the whole of their district. Consumers are to be charged by the actual amount of energy supplied, the rates for the electric light being a minimum of 13s. 4d. per quarter, and for every unit above 20 units 8d. per unit per quarter. Mr. Mellor has passed the order for third reading.

Aberdeen.—The electric light station in Cotton-street was recently thrown open to the inspection of the public. At a meeting of the Gas Committee of the Town Council a letter was read from Prof. Kennedy, giving results of the working of the electric light at the station, from which it appeared that there had been used throughout the area 4,677 units, and at the station 205 units. There had been generated 5,522 units, and the difference between the consumption and output was accounted for by loss sustained in the working through the batteries. The income was £114. 17s. 1½d., and the outlay for wages, etc., was £175. 5s. 3d. There are now 2,950 lamps throughout the city, and the street lamps, which are equal to 172 ordinary lamps, consume about one-seventeenth of the total amount of electricity used.

Tenders for Ayr.—As will be seen from our advertisement columns, the local authority of the burgh of Ayr invite tenders for the supply and erection of the following plant: Section A. Boiler-house plant, including boilers and fittings, mechanical stokers and motor, forced draught apparatus, economiser, feed pump, injector, water-tank, steam, feed, blow-off, and sundry pipes and valves. Section B. Engine-house plant, including steam alternators, steam dynamos, independent condenser, exhaust-pipes, oil-filter, fittings, etc. Section C. Switchboard and instruments. Section D. Underground work, including cables, culverts, brick chambers, and trenching. Section E. Transformers and boxes. Section F. Arc lamps and posts. Section G. Meters. Section H. Overhead crane. Tenders must be sent in by June 23.

Preston Gas and Electric Lighting Bill.—This Bill was on Tuesday before a Select Committee of the House of Commons. It authorises the gas company to construct additional works on a site to the west of the new docks and adjacent to the river; to raise £200,000 by shares and £50,000 by loan, to extend the limits of supply, and to make application, should the company think fit, for a provisional order under the Electric Lighting Acts. The Bill is opposed by Lieutenant-Colonel Fielden and by the Corporation. The latter maintain that the extension of the works is unnecessary, and also that the site chosen for the extension is a bad one. They also oppose the granting of powers to apply for a provisional electric lighting order, the supply of the electric light being already in the hands of a company. The hearing was again adjourned.

Islington.—The Electric Lighting Committee have considered the designs for the electric light station. The successful competitor is Mr. A. Hessel Tiltman, F.R.I.B.A., 70, Torrington-square, W.C. The present plans (which form a first portion only of the future contemplated building) provide the following accommodation: two boiler-houses, each 112ft. by 56ft.; two dynamo and engine rooms, each 112ft. by 44ft.; arc lighting plant-room, 62ft. by 40ft.; testing-room, oil and waste stores, general stores, switch-room, machine and fitting shop, smith shop, stokers' mess-room, cloakroom, etc.; coal store, water-tank for some 120,000 gallons, and offices for the departmental engineers and the general clerical staff. The estimated cost of this first part of the building is about £20,000, and the work is to be immediately proceeded with.

Exhibition at Ashford.—The recent Trades and Inventions Exhibition held at Ashford from April 25 to May 5 last was lighted throughout by electricity, the installation having been carried out by Mr. C. Rawlings, of Maidstone, on behalf of Mr. Richard Dann, of the same town. The installation consisted of a 30-h.p. Tangyes gas-engine, driving a Crompton 200-ampere 110-volt dynamo; a 21-h.p. Tangyes "Archer" vertical steam-engine, driving a Crompton 130-ampere 110 volt dynamo; 20 8-ampere "Byng" arc lamps; and about 280 incandescent lamps. The switchboard was arranged to permit of the dynamos running in parallel, or separately with part load each, or either dynamo to run alone with as many lamps as it would carry. Mr. Rawlings was assisted in carring out the installation by Mr. T. Pierce and Mr. A. Clark.

Dover.—At the quarterly meeting of the Finance Committee of the Town Council, the Surveyor said that the cost of the work done by the Board's men for the electric lighting company was £72. 8s. 10d. and £7. 4s. 10d., 10 per cent., for superintendence, and an order was given for the account to be sent to the company. The Chairman remarked that he was anxious to know whether the Town Hall paid or not, and he would like returns showing the differences in the gas lighting of the hall for three months and electric lighting for a similar period. The Surveyor said there were two meters, but it would be difficult to make the comparison, as only the new hall was to be lighted by electricity. The Chairman said it would be near enough for him if he had the three months for the whole buildings. The electric light should be charged for with the charges for the hall. The Town Clerk intimated that he could get the returns.

Newcastle.—An electric motor is in use in the workshop attached to the Grainger-street establishment of Messrs. Reid and Sons, silversmiths. There it is made to operate the lathes, polishers, and gravers used in the manufacture of gold and silver articles. This work it not only does in the most satisfactory way, but it saves time and labour, and Messrs. Reid and Sons are so satisfied with the result of their Grainger-street experiments that they have resolved to adopt electric motors for their manufacturing operations in Grey-street. A special committee of the Newcastle Corporation met on Tuesday relative to the Corporation undertaking the provision of electricity. After some discussion it was resolved to report to the City Council that it would be desirable for the Corporation to be in a position to supply the city with the electric light. They further decided to ask the Council for a certain sum of money—namely, £200—for the purpose of engaging an expert to enquire into the various systems of electricity in the country, and present a report on the same.

Acton.—The Works Committee of the Local Board reported at a meeting last week that as neither Mr. Medhurst nor his representative attended before them, as promised, they considered that the negotiations as to the electric lighting agreement were at an end. The Chairman remarked that the terms of the proposed agreement were such that Mr. Medhurst could not float a company to take over the electric lighting order from the Board; the Board, the Chairman added, could not sell their order to Mr. Medhurst as a private individual. He hoped some other contractor would come forward and take up the work. Mr. Rome suggested that other contractors should be invited to forward their terms. The Chairman thought it would be better to wait for offers. Mr. Lewsey suggested advertising for tenders for the sale of the order. In reply to questions, the clerk said Mr. Medhurst had no claim upon the Board; the negotiations with him were quite at an end. The Board resolved to advertise for tenders for the transfer of the electric lighting order for Acton.

West Coast of America Telegraph Company.—The seventeenth ordinary general meeting of the West Coast of America Telegraph Company, Limited, was held on Tuesday, Mr. J. Denison Pender presiding. In moving the adoption of the report the Chairman stated that the gross receipts during 1893 were £7,122 less than in the previous year. In 1892 however, the income included £4,728 received from the Chilian Government as compensation for the time the Company was closed up during the war; and, again, in that year the rates of exchange in both Peru and Chili were much more favourable than they had since been. The sterling value of the telegrams transmitted last year was £13,155 odd, against £14,800 in 1892, showing a reduction of £1 677, this being entirely attributable to the decline in the rate of exchange; the actual

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number of words transmitted in 1893 was 131,700 in excess of 1892, so that had the exchange remained the same they would have had a considerably increased revenue. The land line between Buenos Ayres and Valparaiso, constructed by the Pacific and European Telegraph Company, was opened for traffic on March 19 last. The completion of the line restored the direct service between the Company's stations and Europe *vid* Madeira. The service was giving thorough satisfaction to the users of the line, and he was pleased to state that the revenue already received was exceedingly satisfactory. Mr. F. Walters seconded the resolution, which was carried.

The County Council and Electric Lighting.—The Highways Committee of the County Council reported to the latter on Tuesday, in connection with the preparations of the plans, estimates, etc., for the electric light installation for the Victoria-embankment, that the Council on May 8 authorised the retention for a further period of three months of the services of a temporary assistant in the engineer's department. In the committee's report presented on that date the salary of the assistant was wrongly stated to be £3. 3s., whereas £3. 13s. 6d. was the right amount. The committee recommended that the resolution of the Council, relative to the salary of the temporary assistant referred to, be amended by the substitution of the sum of £3. 13s. 6d. for that of £3. 3s. The committee also reported that the House-to-House Electric Light Supply Company had given notice of intention to construct two transformer street boxes at Collingham-gardens. The particulars furnished by the company are insufficient, and it has been asked to supply further details. The committee have sanctioned the laying, by the same company, of mains on the west side of Roland-gardens. The Charing Cross and Strand Electricity Supply Corporation are about to lay mains on the west side of Exeter-street; the Westminster Electric Supply Corporation, on the west side of and across Allington-street; and the Kensington and Knightsbridge Electric Lighting Company of mains along and across New-street, Brompton-road.

The Projected Tramway at Howth.—A public meeting has been held in the St. Lawrence Hotel, Howth, to protest against the tramway which it is proposed to run from Dollymount to the top of the hill of Howth. The chair was taken by the Hon. Judge Boyd, who said they were all aware of the object which had brought them together. The Rev. Mr. Mahaffy would propose a resolution and state the grounds on which they were opposed to the tramway. Rev. Prof. Mahaffy then moved the following resolution: "That the proposed tramway is unnecessary, there being already a convenient train service from Howth to Dublin, and constant communication with the upper hill by long car during the summer months, and by cars and other vehicles at all times. It will prove injurious by disfiguring the scenery, making the roads dangerous, preventing the free passage from one part of the hill to another, and disturbing the peaceful beauty which constitutes the chief attraction of the hill, whether to residents or occasional visitors." He said he did not think it was in the view of the promoters to propose a separate tram line to any part of the way. The better class of people would, he thought, avoid the hill if the tramway was allowed. Mr. Jameson, in seconding the motion, said that the proposed tramway would spoil the appearance of the hill. The motion was adopted. Mr. Culverwell proposed that a committee should be appointed to employ counsel and take other steps on behalf of the inhabitants of Howth to oppose the scheme before the Privy Council. Mr. Maxwell seconded the motion, which was adopted.

The Dover Central Station.—In our last issue reference was made to this station, and we will now amplify our remarks. The plant, which will be laid down at the station by the Brush Electrical Engineering Company for the Dover Company, will be on the alternate-current transformer system. In the boiler-house will be placed three Babcock and Wilcox water-tube boilers. The engines, of which there will be four, will be Raworth's compound vertical inverted type. Two of these engines will be of 175 i.h.p. each; one is 138 i.h.p., and one 84 i.h.p., giving a total of 572 h.p. There will be four alternators mounted on the same bed-plates with the four engines, and connected by flexible couplings, dispensing with the necessity for belting and pulleys. These machines will be of the Mordey-Victoria type Two of these will each be capable of maintaining about 3,400 8-c.p. incandescent lamps. One will maintain 2,600 such lamps, and one 1,700, giving at the commencement provision for 11,000 lamps. There will also be two continuous-current dynamos, each connected with vertical engines, to supply the exciting current to the alternators. Amongst the appliances of the engine-house will be a 15-ton travelling crane for overhauling the machinery, a one-ton portable jib, which can be affixed to any iron pillar in the building, and a four-ton crab. There will also be hydraulic jacks and weighing-machines. The cables will be laid in 2in. cast iron pipes under the roads or pavements. The pressure of the current from the machines will be 2,000 volts, at which the current will be conveyed through the main cables to the transformer stations, where the pressure will be reduced from 2,000 volts to 100 volts, at which it will be supplied to the consumers. The transformers will have a total capacity of 318 kilowatts, and will be capable of maintaining over 10,000 8-candle incandescent lamps. The mode of illumination to be used is two-fold—arc lamps in those parts of the public promenades and main streets which the company has entered into a contract with the Town Council to supply, and incandescent lamps for private lighting. The provision in the contract is for 25 arc lamps of 2,000 c.p.; 16 of these will be set up on the sea-front. The current for these lamps will not be run through the transformers used for converting the consumers' supply, but will be delivered at 2,000 volts pressure at the lamp-post, each lamp having its own transformer. The other arc lamps not used on the sea-front will be placed at intervals along the main thoroughfares.

Electric Lighting for Trains.—We quote the following from the *Railway News*: "Two sets of statements, contradictory to one another, have recently been circulated with reference to the working of the electric lighting system on the trains of the Brighton Railway. On the one hand, it has been alleged that the company's recent experience of this system has been extremely favourable, proving it to be more serviceable and less expensive than lighting by gas. On the other hand, it is said that the company have decided not to extend the electric lighting, but to erect instead extensive works for oil-gas manufacture. We are in a position to state that neither of these statements is strictly accurate, though both contain a modicum of truth It is quite true that the Brighton directors have decided upon the erection of oil gasworks under the Pintsch system both at New Cross and at Brighton, but at the same time they have sanctioned the equipment of eight new trains with electric lighting plant. It seems that the company are engaged in thoroughly overhauling their train-lighting arrangements, but not having formed a decided preference to either system, have resolved to extend both. With regard to the general question of the suitability of electricity for train-lighting, this much seems certain, that in spite of a trial extending over nearly 10 years on the Brighton line, and experiments by the Great Northern, Midland, and other companies, no system yet introduced has thoroughly proved its capacity to meet all the requirements of railway carriage illumination. The Brighton trains cost £400 each to equip, and last year the working expenses for maintenance and renewals were £62 per train. The working cost of new trains, however, will not be so great, because the same number of men already employed to meet the trains and overhaul the apparatus will suffice for a considerable addition to the stock."

The Elmore Companies.—In the course of an article on these companies, the *Financial News* says: "A good many of our correspondents are anxious to know something about the present position of Elmore's Patent Copper Depositing Company. There has been a creeping up in the price of the shares, and holders are naturally desirous of learning to what cause the improvement is due. We should be very glad if we could give them any positive enlightenment; but these shares have on so many previous occasions been made the counters of stock-jobbing transactions, and have been so profitably manipulated by certain financial cliques, that it behoves one to be extremely careful in formulating an opinion without the aid of definite information. One thing is apparent—the rise in Elmore's is not a spontaneous affair. It has been set in motion by somebody, and for some purpose. It is due either to a rig, got up with the object of unloading later on, or to genuine buying on the part of insiders who know of some favourable feature so far not communicated to the general body of the shareholders. During four years the shareholders have watched and waited, now buoyed up with extravagant hopes, now plunged into inconsolable despair. It would, indeed, be a gleam of sunshine worth greeting if Elmore's could, after so many trials, establish itself on a sound paying basis. The progressive character of the business may possibly justify the higher price now quoted for the shares; but we should like some incontrovertible evidence of it before we recommend anyone to buy. Even if the improvement in the prospects warrants a revival of hope, there is a good deal in the financial position that is calculated to check unreasonable expectations. The called-up capital stood, at the end of last year, at £182,390 in ordinary and £17,220 in cumulative preference shares, the latter having been converted from unissued ordinary shares about 12 months ago. In November it was pointed out to the shareholders, and they thoroughly agreed, that as the working capital had been brought down to £4,000—which was obviously inadequate to the requirements of a business which might have to purchase considerable quantities of copper—it was desirable to issue £10,000 of 6 per cent. debentures. Whether the whole of these have been placed or not we do not know; but if not, they, no doubt, will be in the course of time. It will be seen that there are some considerable prior charges to be met annually before the ordinary shares can come in for a dividend, and it must not be forgotten that at June 30 last, when the latest available accounts were made up, there was a debit balance of £21,518, £13,655 of which was loss incurred during the year. There is another point to be looked at in estimating the future value of the shares. Although no action has yet been taken in the matter, it is not improbable that the ordinary capital will be written down to meet the loss incurred in the experimental stages, and by the depreciation in the £12,000 (cost value) of the Wire Company's shares which the Copper Depositing Company holds This reduction was admitted in the 1893 report to be necessary, and although deferred, it may yet have to be carried out, not only as a matter of sound finance, but in the ultimate interests of the shareholders themselves. The fortunes of the other Elmore companies depend more or less on the fate of the one under consideration. The French company, after a huge expenditure and great loss of the shareholders, has gone into liquidation, been reconstructed by a group of French financiers, and possesses no longer anything more than a remote interest for English investors, except those who are directly connected with it, and who may, at some future day, receive back something in the way of dividends if the reconstructed venture manages to score a success. The disastrous collapse of this company, and the only less conspicuous suspended animation of the Austro-German and American promotions, have taken away the occupation of the Foreign and Colonial Company, which existed for the sale of the foreign patents. Whether it will ever

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have occasion to resume its avocations depends entirely upon the future of those Elmore undertakings which are actually at work. It can scarcely be said by any but the most optimistic believer in the process that it has, as a commercial venture, even yet passed completely out of the experimental stage." With regard to this article Mr. J. Shurmur, secretary to the companies, writes as follows: "Referring to your article to-day on this subject, the Wire Company is not suspended pending the raising of more capital. That was our position some months ago, but since then we have allotted over £30,000 of preference shares, and, in addition, our bankers will always finance our copper requirements up to £25,000, which, together, gives us a very substantial working capital at our disposal to-day. Our splendid freehold works and plant, capable of turning out 50 tons a week of unequalled product, were long since paid for to the last penny. The Board has been reconstituted, and the name of our new chairman—Mr. Edward Reynolds, of Sheffield, who is by far the largest shareholder—is a practical guarantee of success. Our sales agents assure us they can readily dispose of four to five times the present possible output at most remunerative prices, and it is now only a question of days before every tank will be fully at work earning a handsome dividend from the first day they start. All our difficulties have vanished. We are to-day closing the London office and concentrating at the works, where I shall always be pleased to see you or any of our shareholders. The present rise is most certainly not a rig; but is, to my knowledge, chiefly due to buying by the customers of the Copper Company, and by the shareholders eager to recoup previous losses."

PROVISIONAL PATENTS, 1894.

MAY 21.

9862. **Improvements in batteries.** William Morison, 29, Broadway, New York, U.S.A. (Complete specification.)

MAY 22.

9896. **Improvements in the arrangement of gearing for electrically-propelled vehicles, cars, yachts, and launches.** George Walter Leech, 49, Great Eastern-street, London.

9909. **Improved shade-carrier for gas and electric shades.** Edward William Lancaster, 52, Bristol-road, Birmingham.

9927. **Improvements in electrical switches and connecting to the same.** Edward Jesse Piper, 34, Victoria-street, Westminster.

9930. **Improvements in signalling on railways, and means therefor.** The Automatic Electric Railway Signal Company, Limited, Edwin Blakey, and John Patrick O'Donnell, 78, Fleet-street, London.

9949. **Improvements in electrolytic apparatus.** Thomas Craney, 45, Southampton-buildings, Chancery-lane, London. (Complete specification.)

9967. **Improvements in electric arc lighting.** Charles Aubrey Day, 321, High Holborn, London. (The Higham Electric Company, United States.) (Complete specification.)

9968. **Improvements in the method of and apparatus for arresting motion of electrically-propelled mechanisms.** Elmer Ambrose Sperry, 321, High Holborn, London. (Complete specification.)

9974. **Improvements in or relating to apparatus for heating metals electrically.** William Phillips Thompson, 6, Lord-street, Liverpool. (Charles Lewis Coffin, United States.) (Complete specification.)

9975. **Improvements in the method of and apparatus for heating, welding, or working metals by electricity.** William Phillips Thompson, 6, Lord-street, Liverpool. (Charles Lewis Coffin, United States.) (Complete specification.)

MAY 23.

9999. **Improved holder for incandescent lamps.** William McGeoch, jun., and Alexander William Stewart, 154, St. Vincent-street, Glasgow.

10018. **Improvements in electroliers or lamps of the kind chiefly employed and known as extension or floor lamps but applicable to other lamps** William Soutter, 3, Cherry-street, Birmingham.

10021. **Improvements in connection with primary batteries and portable electric lamps.** Samuel William Maquay, 55, Chancery lane, London.

10032. **Improvements in and connected with electrolysis and in apparatus connected thereto.** Emile Gautier, 77, Chancery-lane, London.

10044. **An improved system of producing luminous electric changeable writing and in apparatus therefor.** Alfonso Theodoli, 323, High Holborn, London. (Complete specification.)

10045. **An improved method of and apparatus for controlling the action of electric motors and other prime movers.** John Becher Ormsby and George Henry Banister, 45, Southampton-buildings, Chancery-lane, London. (Complete specification.)

MAY 24.

10115. **Improvements in electric lamps for surgical purposes.** Alfred Charles Cossor, 21, Finsbury-pavement, London.

10101. **An improved gripping tool for electric light and other fittings.** Gustav Binswanger and William Everett Gibson, 73, St. Stephen's-road, Upton Park, London.

10114. **An improvement in incandescence electric lamps.** Bennett Pell, 28, Southampton-buildings, Chancery-lane, London.

MAY 25.

10132. **Automatic zero reading electrical instruments.** Joseph Edmondson, Penny Bank-chambers, Halifax.

10140. **Improvements in regulators for electric currents.** Wilson Hartnell, 9, Old Bank-chambers, Park-row, Leeds.

10149. **Improved apparatus for supporting electrical conductors and the like.** John Orme, 21, Finsbury-pavement, London.

10169. **Improvements in plates for secondary voltaic batteries.** Georges Réné Blot, 28, Southampton-buildings, Chancery-lane, London. (Complete specification.)

10171. **Improvements relating to writing telegraphs.** Philip Arthur Newton, 6, Bream's-buildings, Chancery-lane, London. (Elisha Gray, United States.)

10172. **Improvements in or connected with vehicles for electric railways or tramways.** Edward Hopkinson, 47, Lincoln's-inn-fields, London.

10186. **Self-locking cleats for electric wires.** Elias Nashold, 323, High Holborn, London. (Complete specification.)

SPECIFICATIONS PUBLISHED.

1893.

3210.* **Primary batteries.** Maquay. (Amended specification.)

9397. **Electromotors, etc.** Garrard and Blumfield.

10993. **Electric search-light.** Sciama.

12139. **Electric machines and transformers.** Hutin and Leblanc.

12314. **Electrically illuminated signs.** Fricker.

12702. **Electric cables.** Hardingham. (Felten and Guilleaume.)

12850. **Counter of electricity.** Brocq.

13340. **Electric furnaces.** Lake. (Girard and another.)

23902. **Electric motors.** Hall.

1894.

2866. **Dynamo-electric machines.** Wise. (Lewis.)

3108. **Electric railways.** Leffler and Corrigan.

5474. **Electric arc lamps.** Davy.

5816. **Electrical measuring instruments.** Lake. (Weston.)

COMPANIES' STOCK AND SHARE LIST.

Name.	Paid.	Price Wednesday.
Birmingham Electric Supply Company	5	5½-5⅝
Bournemouth Electric Company	—	—
Brighton and Hove Company Original	100	210-215
Brush Company, Ordinary	3	2⅞-3
—— Nom. Cum, 6 per cent. Pref.	2	2⅛-2⅜
—— 4½ Debenture Stock	100	108-111
Charing Cross and Strand	5	4½-5½
Chatham and Rochester	—	—
Chelsea Electricity Company	—	—
City of London, Ordinary	10	12-13
—— 6 per cent. Cumulative Pref.	10	13½-14
—— 5 per cent. Debenture Stock	75	83-85
City and South London Railway, Consolidated Ordinary	100	33-35
—— Debenture Stock	100	117-119
—— 5 per cent. Pref. Shares	10	11½-11⅝
Crompton and Co., 7 per cent. Cum. Pref. Shares	5	3-3½
—— 5 per cent. First Mortgage Debentures—1-400 of £100 and A, 1-200 of £50	100	96-100
Elmore's French Company	2	⅛-¼
Electric Construction, Limited	2	⅛-¼
—— 7 per cent. Cumulative Pref.	2	1⅛-1⅜
Elmore's Copper Depositing	2	1⅛-1⅛
Electricity Supply Company for Spain	5	—
Elmore's Wire Company	2	1-1⅛
Fowler-Waring Cables	5	1-1⅛
W. T. Henley's Telegraph Works, Ordinary	10	6½-7⅛
House-to-House Company	5	1-1⅛
India Rubber and Gutta Percha Works	10	23-24
—— 4½ per cent. Debentures	100	103-106
International Okonite, Ordinary	10	1-2
Kensington and Knightsbridge	5	4⅞-5⅛
Liverpool Electric Supply, Ordinary	5	6⅛-6⅜
—— Pref.	4½	5⅞-6⅛
Liverpool Overhead Railway	10	8⅞-9⅛
—— 4 per cent. Mortgage Debentures of £100	100	110-112
London Electric	5	1-1⅛
Metropolitan Electric Supply	10	7⅛-8
—— 5 per cent. Reg. Debentures, 1-10,000 in Bonds of £10, £20, and £40	—	108-111
National Telephone, Ordinary	5	4⅞-5⅛
—— 6 per cent. Cum. First Pref.	10	15-16
—— 6 per cent. Cum. Second Pref.	10	14½-15½
—— 5 per cent. Nom. Cum. Third Pref.	5	5⅛-5⅞
—— 4½ per cent. Deb. Stock	—	114-116
Notting Hill Company	10	4½-5⅛
Oriental and Electric Company, £1 shares	1	1-1⅛
Southampton Electric Company	—	—
St. James's and Pall Mall, Ordinary	5	6½-7⅛
—— 7 per cent. Pref.	5	8-8⅜
Swan United	3½	1⅛-1⅜
Telegraph Construction and Maintenance	12	39-41
—— 5 per cent. Bonds	100	104-107
Westminster Electric Supply, Ordinary	5	6⅛-6⅜
Yorkshire House-to-House	4½	4⅛-4⅜

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NOTES.

Pfalz.—Bergzabern, Erlenbach, and Bundenthal are to be connected telephonically.

Sheet Lightning.—A new definition of sheet lightning is a harmless method of misrepresentation.

Derby Electrical Exhibition.—This exhibition has been so successful that it is being continued throughout this week.

Pas-de-Calais.—A proposal is under the consideration of the Municipal Council of Auchel for the introduction of electric lighting.

What Next!—It is reported that an electrical man, singing songs, is walking about the streets of New York. He can do 16 miles an hour.

Greifswald.—An urban telephone system is to be established here. It will be connected with the Stettin, Anklam, and Stralsund systems.

Toulon.—The local gas company, who three years ago undertook the supply of electric light, finds that the use of the latter is profitably developing.

Electric Miners' Lamps.—At Woodyet Pit, Denny, Scotland, where a fatal explosion took place last year, year, electric miners' lamps are now employed.

Liverpool Engineering Society.—The members of this society will visit on July 13 the hydraulic power and electric lighting stations of the Manchester Corporation.

Neuminstor.—A central electric light station is to be established here by private enterprise, and many business firms have already declared their intention of taking current.

Nuremberg.—The question of the erection of a municipal electric lighting station is now so far advanced that circulars have been issued to ascertain the probable demand.

The Gas Institute.—A paper on "Gas and Electric Lighting at Blackpool," by Mr. Wm. Chew, of Blackpool, will be read at the annual meeting of the Gas Institute next week.

Appointment.—Mr. Ross, assistant engineer in the office of the Commission of Sewers, was on Tuesday appointed by the Commission as chief engineer, at a salary of £900 a year.

Reduction in Price.—The Kensington and Knightsbridge Electric Lighting Company notify that on and after the 1st prox. the charge for current will be reduced from 8d. to 6d. per unit.

Obituary.—Mr. T. Eccleston Gibb, the vestry clerk of St. Pancras, died on Wednesday at Kentish Town. He was prominently connected with the carrying out of the electric lighting of St. Pancras.

Loyton.—A committee of the House of Commons on Tuesday passed a Bill confirming a provisional order authorising the Leyton Local Board to light the area within its jurisdiction with the electric light.

The Baltic Canal.—For the electric lighting of this canal, to which reference has been made in previous issues, 23 tenders were received. The contract has been obtained by the Helios Company, of Cologne and Ehrenfeld.

The Westminster Electric Supply Corporation. The employés of this Corporation have started a cricket club, and for the remainder of the season they will play at Raynes Park. Mr. W. A. Pearman is the hon. secretary.

The Fulmen Accumulator.—This type of secondary battery is now being exploited in France by a company with offices at 39, Rue de l'Arcade, Paris. These accumulators are intended both for lighting and for traction purposes.

The Hermite System.—A pamphlet has been issued by Messrs. Paterson and Cooper giving opinions of experts on the Hermite electrical sanitation process. It consists of extracts from scientific reports on the method by bacteriologists and chemists.

A Powerful Search-Light.—A Reuter's telegram says that a great search-light constructed in France which was exhibited at the Chicago World's Fair has been erected at Sandy Hook, New York, and was lit for the first time this week. It is of 194,000,000 c.p.

Strassburg.—We have previously referred to Herr von Miller's plans for an electric lighting station for this city. The Municipality now invite tenders by the 15th inst. for the erection and working of a station based on these plans. The work is to be carried out within a year.

London Electric Railways.—The following private Bills were read a second time in the House of Lords on Tuesday: the Central London Railway (Extension of Time) Bill, and the Charing Cross, Euston, and Hampstead Railway Bill. These Bills will pass unopposed through the House of Lords.

Tramways in Cairo.—The Khedivial Government, through the Minister of Public Works, announces an extension of time for receiving bids for the proposed concession for constructing and working a system of tramways in Cairo and environs. The date for receiving offers has been extended to August 1 next.

Londonderry.—The City Corporation have taken over the electric light works. The plant has cost £20,000. The mechanical part has been carried out by Messrs. Alexander Brown and Sons, and the electrical by Messrs. Siemens Bros. and Co., Limited. The matter is referred to more fully in another column.

Electric Propulsion on Canals.—An exhibition of plans for a maritime canal between the Bay of Biscay and the Mediterranean was opened in Paris on Wednesday by a society of promoters. Some competitors propose that vessels should be transported by railway or by rolling docks propelled by electricity.

Electric Lights for French Hansoms.—Hansom cabs are about to be introduced in Paris, the Town Council being willing to encourage the enterprise on the following conditions: 1f. fares, no *pourboires*, or obligatory tips, gutta-percha tyres on the wheels, electric light, and right granted to fares to take parcels or valises for nothing.

Demonstration of Electrometric Apparatus.—An exhibition of Mr. Waterhouse's discoveries in connection with electric meters, dynamos, and telegraph instruments will take place to-day (Friday) at three o'clock at the works of the Waterhouse Electrical Manufacturing Company, Limited, 67, Southwark Bridge-road.

Exhibition in Leicester.—A trades and industrial exhibition is announced to be held in the Floral Hall, Leicester, in the autumn, under the auspices of the Trades Exhibition Company. There will be sections for engineering, inventions, construction, sanitary appliances, decorative work, furniture, electricity, arts and sciences, etc.

Popularising the Electric Light.—The Westminster Electric Supply Corporation who have decided, as previously mentioned, to reduce the charge per unit to 4d. for cooking and heating purposes from the 1st prox., are issuing to

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consumers an illustrated circular setting forth the advantages of electric heating, cooking, and ventilating.

Warnsdorf.—Messrs. Siemens and Halske are moving in the matter of the erection of a central electricity station here. Although a number of factories have their own installations, it is expected that there will be many subscribers. As the gas company's contract will shortly terminate, the promoters hope to be able to get the order to light the streets by electricity.

Private Telephones.—With reference to the note on this subject in our last issue, Mr. Newlands, of the Private Wire and Telephone Installation Company, writes to state that the installation at the *Times* office was put up by the Home Telephone Company, Limited, of which he was manager, and which has recently been absorbed by the National Telephone Company.

The "Electrical Review" v. Harness and Another.—Mr. Justice Hawkins has heard in the Queen's Bench Division the case of Alabaster and another *v.* Harness and another. The action was one for maintenance, the proprietors of the *Electrical Review* alleging that the defendant Harness had maintained an action for libel against them. His lordship reserved judgment.

Junior Engineering Society.—A copy of the *Record of Transactions* of the Junior Engineering Society (vol. iii.) for the twelfth session, 1892-93, has reached us. It contains, as frontispiece, portrait of Dr. John Hopkinson, the president of the society, and also portraits of past-presidents. The *Record* is edited by Mr. Walter T. Dunn, the secretary, and is published at 47, Fentiman-road, S.W.

Bradford Technical College.—For the 160 Bradford County Council free scholarships and exhibitions offered in connection with the Bradford Technical College nearly 200 applications have been sent in. The scholarships offered range in value from 10s. for plumbing to £15 for mechanical, civil, and electrical engineering, and are tenable for two years, subject to a favourable report at the end of the first year.

Electroliers, Standards, and Brackets.—A large illustrated wall sheet of new designs of electrical fittings and portable lamps has been issued by the Edison and Swan United Electric Light Company. The sheet shows some very handsome electroliers, brackets, standards, and pendants. Among other fittings may be mentioned hanging lamps, portable lamps, and ceiling fixtures. This sheet will prove handy for contractors.

All Rights Reserved.—We have always been under the impression that a paper read before any particular society became the property of that society. Possibly we may be under a misapprehension, as the *Building News* of the 1st inst. reproduces, with the words "All rights reserved," a paper presented to the Clerk of Works Association, Carpenters' Hall, by Mr. Henry F. Joel, on "Electricity as Applied to the Lighting of Buildings."

The Underground Railway.—In the House of Commons on Monday Mr. Weir put some questions to the President of the Board of Trade with respect to the ventilation of the Metropolitan Railway Company's line. He also wanted to know if the President would enquire whether electric traction might not be introduced, to which Mr. Bryce replied that everybody knew that it was a matter that could be avoided if electric traction were adopted.

Telephony in Austria.—Herr Ritter von Obentrant has given some information with respect to the intentions of the Austrian Government with respect to telephony. It is proposed to establish telephonic communication between Vienna and Berlin, and in addition there will be a telephonic extension westwards to Linz, and a connection between the towns of Brünn and Olmütz. This last line will be connected with the Silesian telephone network.

A Three-Filament Incandescent Lamp.—Messrs. Bartzsch and Co., 11, Stephenstrasse, Berlin, have patented an incandescent lamp in which there are three filaments, so that either 5 c.p., 10 c.p., or 20 c.p. can be obtained respectively, or any combinations of these powers. The socket of the lamp contains a switching apparatus, which allows of any or all of the filaments being switched on. It is, however, difficult to see the practical utility of this lamp.

Laying of New Mains.—The Woolwich District Electric Light Company intend to lay a short length of main in High-street, Woolwich. The House-to-House Electric Light Supply Company are about to lay mains and construct street boxes in Longridge-road, north side, between Earl's Court-road and Templeton-place; and the Kensington and Knightsbridge Electric Lighting Company propose to place underground mains in Albert-place and Douro-place, Victoria-road.

New South Wales.—We have received a copy of the annual report of the works carried out by the Department of Public Works of the New South Wales Legislative Assembly during 1892. The report mentions that the North Shore cable tramway extension was opened for traffic on July 16, and that the Military-road electric tramway was opened on September 20, the electric plant which was in use on the Randwick-Waverley line having been transferred to this tramway.

Electro-Metallurgy in France.—The report of the Société Electro-Metallurgique Française, of Forges (Isère), shows that the position of the company during 1893 was satisfactory, and that the profits allowed of a dividend of 6 per cent. on the paid-up share capital. The company's works at Praz, near Modane, produce 10cwt. of aluminium daily, and it is expected that those works will shortly utilise the water power which the company have at their disposal, to the extent of 3,000 h.p.

Lighting at Torquay.—In a paper read on Saturday before the Association of Municipal and County Engineers at Torquay, Mr. H. A. Garrett (the borough engineer) stated that the Corporation has had the subject under consideration for several years, and that in 1890 they obtained a provisional order. He has made a preliminary report upon the probable cost of an installation to cover the compulsory area, and the advice of an expert has also been called in. The Corporation has, however, not yet proceeded in the matter.

Electricity in Mining.—Mr. A. H. Stokes, the inspector of mines for the Midland district, states that in mines worked with safety lamps all shots should be fired by electricity and low-tension fuses. The simplicity and certainty of firing by the low-pressure system of electric blasting commends itself to all who have adopted its use. The electric fuse can be safely tested before being taken into the mine, and little fear, he concludes, need be entertained that the operatives will be troubled with mis-shots, and the weight of the firing apparatus need not prevent its general use.

Gas-Engine Plant.—A gas-engine installation has been laid down at Carrignan, in the Ardennes, in which poor or inferior gas is used for the engine. According to the *Génie Civil*, the gas-engine employed is of the MM. Delamare-Debouteville and Malandin type of 60 effective horse-power; the gas producer is of the Buire-Lencauchez class, gasifying small coal, and the consumption is said to be 650 grammes per effective horse-power. The generating station contains the gas-engine and dynamos. There are three dynamos of a total capacity of 35 kilowatts, and

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these are used either to charge accumulators or to supply current direct for lighting.

Portraits by Telegraph.—A Paris telegram says that M. Bertillon, the inventor of the anthropometrical system adopted by the Paris police, and head of the department in which the system is worked, is endeavouring to revive the use of the Pan-telegraph, an apparatus for the transmission of portraits and sketches by telegraph. The apparatus was tried for the transmission of autograph messages some years ago, but the experiments were discontinued in 1877. M. Bertillon considers that the Pan-telegraph would be of the greatest use in view of the fact that portraits of suspected Anarchists or of criminals are constantly being forwarded by the police of one country to another.

The E.P.S. Pocket Catalogue.—A handy and useful pocket catalogue has been brought out by the Electrical Power Storage Company, Limited, in connection with the employment of E.P.S. cells. Those who are about to use this type of battery will be interested both in the concise instructions given in the booklet for erecting the E.P.S. cells, and in the directions printed therein as to the methods of charging and discharging the batteries, whilst the latter information will also be of value to the youngsters already engaged in some capacity or other in private installations and in central stations. A large amount of data is likewise given concerning the various types of E.P.S. cells, and the table of the cost of renewals of plates should be useful.

A Lesson to a Yaller Dog.—A German friend has been troubled by a yaller dog that used to enter his kitchen and seize any food lying about. To get at the meat in the safe, the dog with his broken teeth would even grip the door handle, turn it, open the door, and march off with his prey. The dog thought he knew a thing or two, but our friend could not stand this from a snarling dog that was always barking and could not bite. So one day he suspended from the ceiling just in front of the safe a tremendously large horseshoe magnet. Nothing happened until the third morning, when on entering the kitchen our friend discovered the dog, which wore a broad metal collar, suspended by the latter from the magnet. Now that yaller dog cannot bark, much less bite, and another lesson like he received that morning will teach him to cease snarling.

Electricity at Gotha.—The new electricity station which has been erected by Messrs. Lahmeyer and Co., of Frankfort-on-the-Maine, has been formally opened. A notable feature is that the station serves for the supply of current to an electric tramway, and also for the supply of current, direct and indirect, for lighting purposes. At the central station two steam-engines, made by the Munich Machinery Company, Limited, drive two high-tension and two low-tension dynamos. The former supply current at 550 volts to the tramway and to a transformer station in the centre of the town. The two low-tension dynamos supply current direct for lighting purposes on the three-wire system. At the transformer station the high tension is reduced to low tension, and employed partly for charging accumulators and partly direct for lighting purposes. There are 3,300 lamps connected, and notice has been given for 700 more.

Lighting of the Embankment.—The London County Council on Tuesday adopted the report of the Highways Committee, who reported that they had approved of the plans, specification, and estimate for the generating station, to be constructed near the Charing Cross Station of the Metropolitan District Railway, for the lighting by electricity of the Victoria-embankment and the Waterloo and Westminster bridges, the amount of the estimate being £5,000. It was important, the committee submitted, that the work should be carried out without delay, and they therefore recommended that, subject to an estimate being submitted to the Council by the Finance Committee, the generating station should be constructed by the Council without the intervention of a contractor; and that the plans, specification, and estimate be referred to the Works Committee for that purpose, with instructions that the work shall be carried out with all possible expedition.

High-Pressure Direct-Current Transmission.—With reference to the article given in our issue of May 25 on "The Transmission of Electrical Energy by High-Pressure Continuous Currents," Mr. O. Görling, of Nuremberg, writes that the proposal of Mr. Schultz comes rather late in the day. Mr. Görling says that several installations of this character have been carried out with complete success, and that Messrs. Schuckert and Co. undertook a power transmission contract at Sigmaringen. In this case there are four primary dynamos of 1,100 volts at the generating station, and four motors at the end of the transmission. Each pair of dynamos is connected in series, giving current at 2,200 volts. The distance separating the primary and the secondary stations is 3·1 miles, and an equalising wire is used. At the secondary station the current is transformed down to 220 volts, and is by means of a battery of accumulators distributed on the three-wire system.

The Institution Conversazione.—The conversazione of the Institution of Electrical Engineers took place on Thursday of last week, Mr. Alexander Siemens (the president) and Mrs. Siemens receiving the guests. Among others present were the following: Sir Frederick Abel, Bart., Prof. W. Grylls Adams, Dr. H. E. Armstrong, Prof. W. E. Ayrton, Sir Benjamin Baker, Sir Frederick Bramwell, Bart., Sir J. Crichton Browne, Mr. R. E. Crompton, Prof. William Crookes, Mr. Latimer Clark, Sir John Evans, Mr. S. Z. de Ferranti, Dr. J. A. Fleming, Prof. G. Carey Foster, Mr. C. Hawkesley, Dr. John Hopkinson, Prof. D. E. Hughes, Sir R. Hunter, Prof. A. B. W. Kennedy, Admiral Kinahan, Prof. O. J. Lodge, Sir Henry Mance, Prof. John Perry, Mr. W. H. Preece, Earl Russell, Sir David Salomons, Bart., Sir E. M. Shaw, Mr. C. E. Spagnoletti, Mr. J. W. Swan, Mr. G. J. Symons, Prof. S. P. Thompson, Mr. John Thornycroft, General C. E. Webber, and Sir H. Trueman Wood.

Electric Shocks.—In a communication to the Paris Academy of Sciences, M. d'Arsonval draws attention to the fact that in cases where persons are subjected to the shock of a powerful electric current, death, as in cases of drowning, is often only apparent. Not long ago, he declares, a workman at Saint-Denis, after having been subjected for several minutes to a current of 4,500 volts, was restored to consciousness in a very short space of time, although for three-quarters of an hour he had been left alone, as it was supposed he was dead. It was a Dr. Laborde who was called in, and who resorted to artificial respiration with complete success. M. d'Arsonval, therefore, considers it is important to bear in mind that persons who have been rendered insensible by electric discharges should be treated like those who are rescued from drowning. He thinks that criminals who are "electrocuted" in America are in reality alive after the shock, although they remain insensible, and die shortly in the absence of restoratives.

A Secondary Battery.—Our contemporary *Cosmos* describes in its issue of the 2nd inst. a new type of secondary battery, but omits to mention the name of the inventor. A watertight wooden box contains a certain

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number—say, six for instance—of ordinary porous pots, each containing a carbon plate having at its upper end a copper terminal. These pots are filled with chloride of lead, arranged round, and in good contact with, the carbon. Round each pot is placed a cylinder of carbon forming the positive electrode, and being in connection with the others by means of a carbon plate arranged at the bottom of the box. The negative electrodes are in communication by copper connections. The cell is filled with a solution of protochloride of iron (60 per cent.), and the battery is then ready to be charged. Theoretically, the battery should yield a horse-power hour per 3·3 kilogrammes of metal. In practice, our contemporary states that it has obtained 50 ampere-hours per kilogramme of active material.

Promiums Awarded by the Institution of Civil Engineers. — A detailed list of the awards made by the Institution of Civil Engineers for original communications submitted during the past session has been issued. The following awards have been made for papers read and discussed at the ordinary meetings: Telford medals and Telford premiums to Mr. J. H. Greathead, M.I.C.E., and Mr. Francis Fox, M.I.C.E., for their joint paper on "The Liverpool Overhead Railway," and a George Stephenson medal and a Telford premium to Mr. Thomas Parker, M.I.C.E., for his paper on "The Electrical Equipment of the Liverpool Overhead Railway." For papers printed in the *Proceedings* without being discussed, a Watt medal and a Telford premium have been awarded to Mr. Bryan Donkin, M.I.C.E., for his paper entitled "Experiments on the Condensation of Steam in Cylinders of Iron and other Metals," and a Telford premium to Mr. G. Croydon Marks, A.M.I.C.E., for his paper entitled "Cliff Railways."

A Mountain Electric Railway.—A mountain railway has for some time past formed a means of communication between Interlaken and Lauterbrunnen, and this has been extended by carrying a further length from the latter place to Murren *vid* Grütsch. The first section of this railway is a three-rail rack line from Lauterbrunnen to Grütsch, and the second section to Murren is worked by electric cars, the distance being nearly three miles. The track in this case is also formed of three rails, and an electric locomotive hauls either two or three cars, according as may be required. Each locomotive is equipped with two 30-h.p. motors, which receive current from an overhead trolley wire, the supply being provided from a generating station situated three-quarters of a mile distant. The return is formed by the rails. The generating station contains turbines of 150 h.p., the water power being obtained from a neighbouring torrent. The turbines drive direct-current dynamos coupled on the same shaft and yielding 150 amperes at 600 volts. The journey on the electrical section of the line occupies 25 minutes. The French journal *Cosmos* of June 2 gives illustrations of the line.

Definition of Inductance.—The American Institute of Electrical Engineers, in assembly at Philadelphia, have adopted the report of the Committee on Units and Standards. The committee recommended that the definition of the term "inductance" shall be identical with that of the coefficient of self or mutual induction, or L. The report stated that the opinion in regard to the definition of this term had been asked of the national electrical professional bodies of Great Britain, Germany, Austria, and France; that the two former were strongly in favour of defining it as being identical with the coefficient of self-induction; that the Electrotechnischer Verein of Vienna had expressed no opinion, and was indifferent; and that the Société Internationale des Electriciens had expressed the opinion that the word should be defined as a coefficient of induction into an angular velocity. On the motion of Mr. Steinmetz, the word "reactance" was adopted for that quantity in an alternating-current circuit whose square added to the square of the resistance is the square of the impedance—that is, the quantity between brackets in the expression

$$C = \frac{E}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}}.$$

Transmission of Power.—An interesting installation of the transmission of power has been completed at the works of MM. Meunier at Noisiel, where the chocolate well known under the former name is manufactured. The chocolate factory, which is erected on the banks of the Marne, is equipped with three turbines of 200 h.p. A little over a mile and a half distant is situated a model farm, where practically everything employed in agricultural operations may be seen. The object of the electrical plant is to utilise a portion of the power of the turbines, and to transmit the electrical energy to the farm for lighting purposes, and for the operation of agricultural appliances. The installation has given good results. The generating station, situated on the bed of the Marne, contains, as already mentioned, three turbines of 200 h.p., provided with vertical shafts, and capable of utilising a fall of water, the height of which varies from 3ft. 4in. to 13ft. 4in., according to the season. These turbines, by means of suitable gearing, all work on to a common horizontal shaft, from which the machinery in the chocolate factory is driven. Arranged on this shaft is a pulley, from which the exciter for the alternator is driven. The exciter is of the two-pole class, giving, at 1,800 revolutions, 15 amperes at 90 volts. The alternator, which is of the Brown type, is actuated from the common shaft. It is a two-phase machine of 75 h.p., having eight poles, and furnishing 165 amperes at 150 volts, at a speed of 600 revolutions. The current is transmitted to the farm in question, and is there utilised for the purposes mentioned.

The Tramways Institute.—Mr. J. G. B. Elliot, the secretary, states that at a conference of the members and associates of the Tramways Institute of Great Britain and Ireland, held in Manchester in April, the president mentioned that an opinion had been expressed that the institute devoted too much time to mechanical traction to the exclusion of other matters of interest. This can scarcely be considered quite correct, as reference to past records will show. He further says that the executive has always been most desirous to receive papers upon all subjects appertaining to tramways interests, and in bringing this question to the notice of tramway men, he urges upon them the desirability of sending a paper upon any subject which they may consider should be fully discussed. Thirty-two companies are already members of the institute, representing 262 miles of line and £4,500,000 of capital; but as the necessity for remedial legislation becomes daily more urgent, and the pressure of proposals to damage tramway property is becoming severe, the council invite the serious consideration of tramway shareholders to the urgent necessity for themselves supporting, not by their moral weight merely, but in the manner indicated below, an institution formed solely for their benefit. It is urged upon all tramway shareholders (1) that they should personally become associates of the institute; (2) that they should, by personal interview or correspondence with the member of Parliament representing their particular constituency, induce him to support an enquiry into the operation of the Tramways Act, with a view to its amendment on the large and important matters which experience has proved require

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alteration and improvement, and the removal from the companies of the grossly unjust impositions to which they are now subjected; and (3) to resist the attempts constantly being made to depreciate their property.

The Scientific Work of Hertz.—Prof. Oliver Lodge discoursed last Friday before the Royal Institution on the "Scientific Work of Hertz." Prof. Lodge described Hertz, who died only some five months ago in the prime of life, as the founder of an epoch in experimental physics, and said that by his death a distinct gap had been caused in the front rank of scientific investigators. Clerk Maxwell had elaborated the mathematical theory of the propagation of E.M.F. by means of waves in the ether. The great work of Hertz's life was to supply experimental verification of that theory. The first experiment was to illustrate the manner in which electric waves emitted from a primary circuit may be picked up by a suitable secondary circuit. The activity of the secondary circuit was manifested by the sparks which occurred at the spark-gap simultaneously with the discharge of the primary. Hertz noticed the curious fact that these sparks pass more easily if they are exposed to the light of the primary discharge. It has been inferred that the ultra-violet rays are in this case the active part of the light, since the interposition of a sheet of glass, which cuts off the ultra-violet rays, is sufficient to destroy the effect. Light, too, falling on a body negatively charged with electricity, greatly accelerates discharge, but has very little effect if the charge is positive. A piece of wire pressing lightly upon a plate of some oxidisable metal, so as to make a bad electrical contact, constitutes an extremely delicate detector. A Hertzian wave falling on it at once makes the contact good, so that a galvanometer is affected. A "coherer" of this kind was shown to be sensitive to a wave radiated from a small sphere some 20 or 30 yards distant. The lecturer suggested that the eye is an electrical instrument of something the same kind, consisting of some material which (like selenium) becomes a conductor under the influence of light.

Power Transmission by Polyphase Currents.—The Jura-Simplon Railway Company decided some time ago to utilise the water power of the River Suze, about a mile and a quarter from the town of Bienne, for their works at the latter place, and entrusted the installation to Messrs. Lahmeyer, of Frankfort, particulars respecting which are given in *Electricité*. The system of distribution which they adopted was similar to that which they employed at the Bockenheim central station. In this system, high-pressure polyphase current is generated at the primary station and sent over the conductors to the secondary station, where part of it is used direct, without being transformed, for driving polyphase-current motors. The balance is transformed into continuous low-pressure current, distributed in the neighbourhood of the secondary station. Continuous low-pressure current is also supplied in the neighbourhood of the primary station from the dynamos used to excite the polyphase alternators. The primary station is installed in a mill on the banks of the Suze, and water is led to it from the river by a canal, 850 h.p. being available. There are two small turbines of 150 h.p. combined for driving the mill, leaving 700 h.p. available, and only half of this is used for the transmission plant, leaving 350 h.p. still not utilised. The buildings are arranged so that duplicate machinery with another turbine can be put in so as to double the electrical output. The existing turbine for the electrical plant is of 275 h.p., and has been made by Messrs. Rieter, of Winterthur. The two generating dynamos, which are coupled direct to the turbine shaft, produce polyphase current at 80 volts. Two Lahmeyer continuous-current dynamos are driven from the same shaft by belt, and serve to excite the alternators. The high-tension current, after having been stepped up to 1,800 volts, is led from the primary station to the secondary station by six bare wires, forming two lines, which are carried overhead. One of these goes to the repairing shops of the railway company at Bienne, and the other to the railway station. At the sub-station at Bienne the current is transformed by a dynamo-motor to a continuous current of 110 volts. Part of the current is utilised for charging accumulators used for lighting the railway trains, and part for lighting the station and yards. At the shops the current is mainly utilised in driving machine tools. The machinery at the primary station is so simple that it is allowed to run by itself, a man employed at the mill looking in occasionally. The railway company pays the mill proprietor, who owns the works, ·04d. per horse-power hour on the running of the turbine.

Christiania Electricity Works.—The results of the working of this station during 1893 have been published. On January 1, 1893, there were connected 2,560 lamps (or their equivalent) for private lighting, 500 for street-lighting, and 183 for the central station, making a total of 3,243. On January 1, 1894, the numbers had increased to 9,930 for private lighting, the equivalent of 1,050 for motors, 500 for street-lighting, and 183 for the central station, making a total of 11,663. The works have made tests as to the consumption of current by the incandescent lamps—the illuminating power of each at the commencement being 16 c.p.—and the influence of the cost per lamp-hour, which appear in the following table:

Class of Lamp.	Number of lamps tested.	Average life of lamp in hours.	Average illuminating power at end of test.	Average illuminating power.	Effective consumption in watts.
General Electricity Company, of Berlin	23	500	11·2	13·6	44
American Edison	19	450	10·88	13·44	44
Venloo incandescent lamps	30	113	16	16	59·6
The Stockholm Glow Lamps Company	2	785	11	13·5	52

The total production of current in 1893 amounted to 312,211 kilowatts, of which 301,483 kilowatts went into the conductors, the balance of 10,728 kilowatts being lost in the accumulators. Of the current delivered into the conductors there were used: by private consumers for lighting, 193,256 kilowatts; by private consumers for technical purposes, 7,971 kilowatts; for public lighting, 70,328 kilowatts; and by the station itself, 9,861 kilowatts; total, 281,416 kilowatts. Thus, the efficiency of the output of the current delivered from the conductors is 93·3 per cent., and compared with the current produced at the station of 90·1 per cent. Current is delivered to consumers at a pressure of 107 volts. The total consumption of coke was 1,091,690 kilogrammes (1,091 tons). Each kilogramme (2·2lb.) of coke produced 286 watts at the station and 258 watts at the consumers. The average daily consumption in kilowatts was as follows: January, 944; February, 1,026; March, 777; April, 508; May, 295; June, 120; July, 125; August, 360; September, 752; October, 1,242; November, 1,752; and December, 2,053. The accumulators consisted of 138 cells, with a normal capacity of 643 ampere-hours, and a maximum discharge current of 193 amperes. The total efficiency was 74 per cent., or 4 per cent. more than was guaranteed. The income for the first working year was 160,581 crowns, leaving a balance of profit of 42,085 crowns.

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PHYSICAL UNITS.

BY MAGNUS MACLEAN, M.A., F.R.S.E.

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§ 1. In physical science it is essential to have certain definite units in terms of which results of observation, and physical quantities dealt with generally, can be expressed. The object of the writer of this series of articles is to discuss these physical units, and the inter-relations among them, in an elementary, clear, and concise manner. All physical units may be divided into fundamental units and derived units. That is, a few units are chosen and fixed arbitrarily, so that all other units in physics can be expressed in terms of them; then the former are said to be fundamental units, and the latter to be derived units. Theoretically, any three independent units* are necessary and sufficient, so that the selection of the three fundamental units is one of convenience rather than of necessity. The three fundamental units so chosen are: the unit of length, the unit of mass, and the unit of time.

§ 2. Unfortunately for students in physics, there are two systems of units—the British system and the metric or French system. The latter is so much simpler that experimental results will generally be expressed in metric units (centimetre-gramme-second units, or C.G.S. units). But there are many results which are so well known and so conveniently expressed in British units, that we shall follow the usual custom and give them in British units.

§ 3. The British unit of length is the Imperial yard. It was enacted by Parliament (18 and 19 Vict., c. 72, July 30, 1855) "that the straight line between the centres of the transverse lines in the two gold plugs in the bronze bar deposited in the office of the Exchequer shall be the genuine standard yard at 62deg. F., and if lost it shall be replaced by means of its copies," which are preserved at the Royal Mint, the Royal Society of London, the Royal Observatory at Greenwich, and the new palace at West minster. The unit generally used is a foot, which is a third of a yard.

§ 4. The French unit of length is a metre, and is defined as the distance between the ends of a rod of platinum made by Borda, the rod being at the temperature of melting ice. This length was originally intended, according to the measurements of Delambre and Mechain, to be the ten-millionth part of the earth's meridian passing through Paris. But its definition is really the length of Borda's platinum rod, as above stated. The unit generally used is a centimetre, which is the one-hundredth part of a metre.

§ 5. The British unit of mass is the Imperial pound. It is the weight of a piece of platinum marked "P.S., 1844, 1lb." deposited in the office of the Exchequer, and the Act quoted above states that it "shall be the legal and genuine standard measure of weight, and shall be and be denominated the Imperial standard pound avoirdupois, and shall be deemed to be the only standard measure of weight from which all other weights and other measures having reference to weight shall be derived, computed, and ascertained, and one equal seven-thousandth part of such pound avoirdupois shall be a grain, and five thousand seven hundred and sixty such grains shall be and be deemed to be a pound troy. If at any time hereafter the said Imperial standard pound avoirdupois be lost or in any manner destroyed, defaced, or otherwise injured, the Commissioners of Her Majesty's Treasury may cause the same to be restored by reference to or adoption of any of the copies aforesaid, or such of them as may remain available for that purpose."

§ 6. The French unit of mass is the kilogramme des Archives, and though originally intended to be the mass of a cubic decimetre of distilled water at the temperature of 4deg. C., it is really defined as the mass of a piece of platinum constructed by Borda in accordance with a decree of the French Republic in 1795.

* See a paper by A. W. Rücker, M.A., F.R.S., "On the Suppressed Dimensions of Physical Quantities," *Phil. Mag.*, vol. 27, year 1889, page 104; a paper in the same volume, page 178, by T. H. Blakesley, M.A., M.I.C.E., "On Some Facts Connected with the Systems of Scientific Units of Measurement"; also a paper by W. Williams, "On the Relation of the Dimensions of Physical Quantities to Direction in Space," *Phil. Mag.*, vol. 34, year 1892, page 234. Reference will be made to these and other papers in subsequent articles.

The metric system is decimal; Greek prefixes denoting multiplication, and Latin prefixes denoting division.

1 kilometre	= 1,000 metres.	1 kilogramme	= 1,000 grammes
1 hektometre	= 100 ,,	1 hektogramme	= 100 ,,
1 dekametre	= 10 ,,	1 dekagramme	= 10 ,,
1 metre	= 1 ,,	1 gramme	= 1 gramme
1 decimetre	= $\frac{1}{10}$ metre	1 decigramme	= $\frac{1}{10}$,,
1 centimetre	= $\frac{1}{100}$,,	1 centigramme	= $\frac{1}{100}$,,
1 millimetre	= $\frac{1}{1000}$,,	1 milligramme	= $\frac{1}{1000}$,,

The relations between the British and metric units of length and mass are:

1 yard = 0·9143835 metre.
1 metre = 1·0936331 yards = 39·37079 inches.
1 pound = 0·453593 kilogramme.
1 kilogramme = 2·2046213 pounds.

The following are, however, near enough approximations:

1ft. = 30·48cm.
1lb. = 453·6 grammes.

§ 7. It will be noticed that in the British Act of Parliament the word "weight" is used to signify the quantity of matter within a body, whereas when it is used in its proper scientific sense, it signifies the downward force of gravity on the body. The distinction between weight and mass has been excellently put by Clerk Maxwell in his "Theory of Heat," tenth edition,* page 79, from which I quote: "From these legal definitions it will be seen that what is generally called a standard of weight is a certain piece of platinum—that is, a particular body, the quantity of matter in which is taken and defined by the State to be a pound or a kilogramme.

"The weight strictly so called—that is, the tendency of this body to move downwards—is not invariable, for it depends on the part of the world where it is placed, its weight being greater at the poles than at the equator, and greater at the level of the sea than at the top of a mountain.†

"What is really invariable is the quantity of matter in the body, or what is called in scientific language the mass of the body, and even in commercial transactions what is generally aimed at in weighing goods is to estimate the quantity of matter, and not to determine the force with which they tend downwards.

"In fact, the only occasions in common life in which it is required to estimate weight considered as a force is when we have to determine the strength required to lift or carry things, or when we have to make a structure strong enough to support their weight. In all other cases the word weight must be understood to mean *the quantity of the thing as determined by the process of weighing against 'standard weights.'*

"As a great deal of confusion prevails on this subject in ordinary language, and still greater confusion has been introduced into books on mechanics by the notion that a pound is a certain force, instead of being, as we have seen, a certain piece of platinum, or a piece of any other kind of matter equal in mass to the piece of platinum, I have thought it worth while to spend some time in defining accurately what is meant by a pound and a kilogramme."

§ 8. On Saturday, April 2, 1892, the standard yard measure and the standard pound weight, which for twenty years previously had lain in the wall of the great staircase leading to the Committee corridor of the House of Commons, were taken out for the purpose of comparison with the Imperial yard and pound in common use. The standards were first deposited in the wall in 1853, and this was the third test to which they were subjected. The standard yard, which is a bar of bronze, was enclosed and sealed in an oak box, and the standard pound,

* See also *Nature*, May, 1894, correspondence columns, signed "K," "The Reviewer," "Minchin."

† One pound weight

$$\doteqdot 32{\cdot}17\,(1 - 0{\cdot}00257\cos 2\lambda)\left(1 - \frac{5}{4}\frac{h}{r}\right) \text{ poundals.}$$

Where λ is the latitude of the place of observation;
h is the height above the sea-level; and
r is the radius of the earth—approximately 21×10^6 feet.

One gramme weight

$$\doteqdot 980{\cdot}5\,(1 - 0{\cdot}00257\cos 2\lambda)\left(1 - \frac{5}{4}\frac{h}{r}\right) \text{ dynes.}$$

The average value in the British Isles may be taken as
one pound weight $\doteqdot$ 32·2 poundals.
one gramme weight $\doteqdot$ 981 dynes.

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which is of platinum, was deposited first in a silver-gilt case, next in one of solid bronze, then in a mahogany box, fourthly, in a leaden case, and, lastly, in a mahogany box. The weight is first wrapped in a peculiar kind of Swedish paper, quite free from silica, and therefore not liable to cause friction.

The observer at the end of the test said: "I have finished the comparison of the immured standards with the Imperial standards, and I find that they are in the same condition as when they were deposited in 1872. The comparison has been made within the following limits: the pound has been compared within the ten-thousandth part of a grain, and the yard measure within the one-hundred-thousandth part of an inch."

(To be continued.)

THE MUNICIPAL ELECTRIC LIGHT STATION AT BURTON-ON-TRENT.

The Two B's.

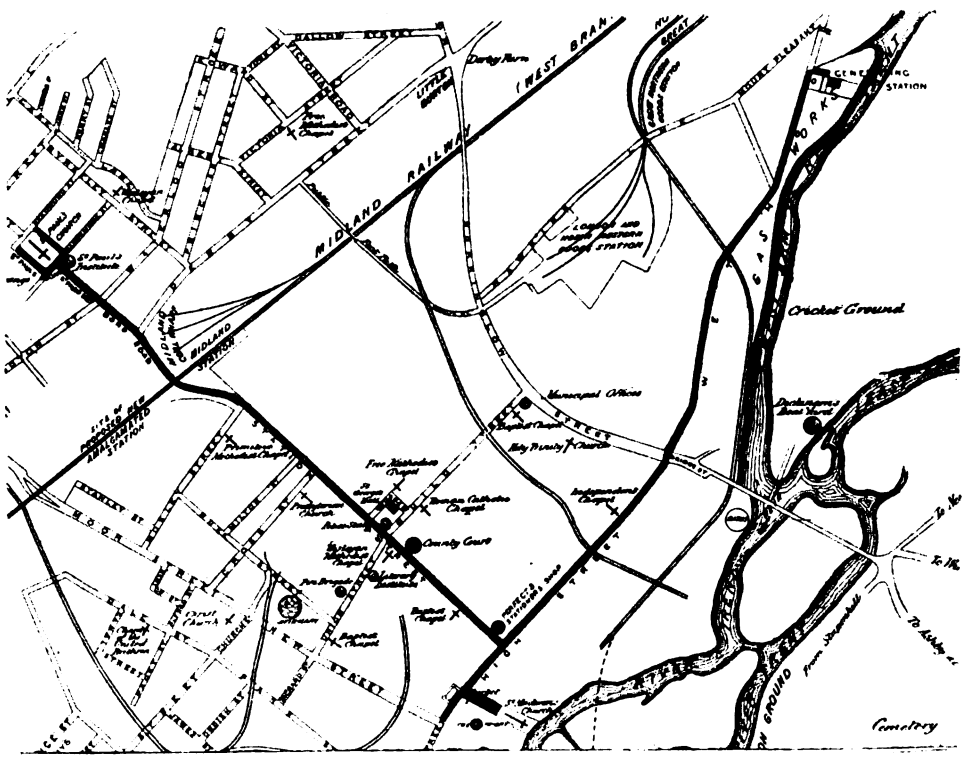
The town of Burton-upon-Trent is something like a four hours' journey by the Midland Railway from the Metropolis. No doubt the 127 miles separating the two would be accomplished in less time were it not for the changing of trains at Leicester, where the traveller has to complete the remainder of the distance by local train stopping at most stations leading on towards Burton. At the same time, a view of the town alone amply repays a visit. Famous for its immense breweries, which form the staple trade of the town, Burton beer and ale have a wide reputation throughout the world. Probably most of the largest brewery firms in the kingdom are located there, the various works being connected by large sidings with the railway, and the traffic being dealt with by tank locomotives owned by the brewers.

The Burton beer is said to be excellent. Our representative had not time to taste it locally on the occasion of his recent visit. He has, however, tried it in town, and found it good—when he got the genuine article. But they go a step further in Burton. They say the beer sold there is superior to that obtainable outside the town, although originating from it. No doubt it is. It must be so, if it is correct, in connection with the sewage-disposal question, that even the rooks and the crows get intoxicated through drinking the liquid sewage. It is a very good thing for the Town Council that the difficulties in regard to the sewage problem are being overcome, otherwise the Council might be summoned for permitting drunkenness on the public highway. It is really no joke for a Burtonite, as our representative was assured frequently happens, when walking out with his best girl and Sunday topper, to feel a sudden bang on his head, his hat crushed in, and hearing an inebriated bird crowing "Bass, Bass," and seeing it flying zigzag down the street.

But the inhabitants are totally different. Many of them, if not the majority, are engaged in the production of beer, and familiarity apparently breeds contempt. There are two decent hotels, the Queen's and the Midland, so you will know where to stop when you pay a visit. The town is in a prosperous condition, and the liberality of the brewers to the town and to their workmen is well known. Well, they can afford to be lavish at times. Mr. Worthington, it seems, has just presented £10,000 to the local infirmary, but more money is wanted. They'll get it—out of beer.

The Dinner to the Corporation.

The reason for these introductory and somewhat discursive remarks is to be found in the completion of the municipal electric light station at Burton by the contractors, Messrs. John Fowler and Co. (Leeds), Limited, who in celebration thereof gave a complimentary dinner last Friday to the Corporation and a number of guests at the St. Paul's New Institute. It was a cheery gathering. There was not a dull moment during the four and a half hours occupied over the dinner and the toast list, the latter being suitably interspersed with music. Messrs. B. Verity and Sons had wired the institute, and fitted up some pretty five-light electroliers and table lamps, which were switched on for the first time that evening.



Burton-on-Trent—Map of District.

Dinner over—a capital one, by the way—Mr. H. Fowler (the chairman) proposed the toast of "The Queen," which was duly honoured. In toasting the "Mayor and Corporation," he mentioned that the town of Burton was one of the first to obtain a provisional order. When it was granted, a specification was got out, and the result was the station which they had seen that day. The town was extraordinary in combining the gas undertaking with the electric light station. It was the most sensible thing any town could do. It would be difficult to say what the cost of fuel would be in Burton, seeing that that used was almost worthless at the gasworks. The adoption of the

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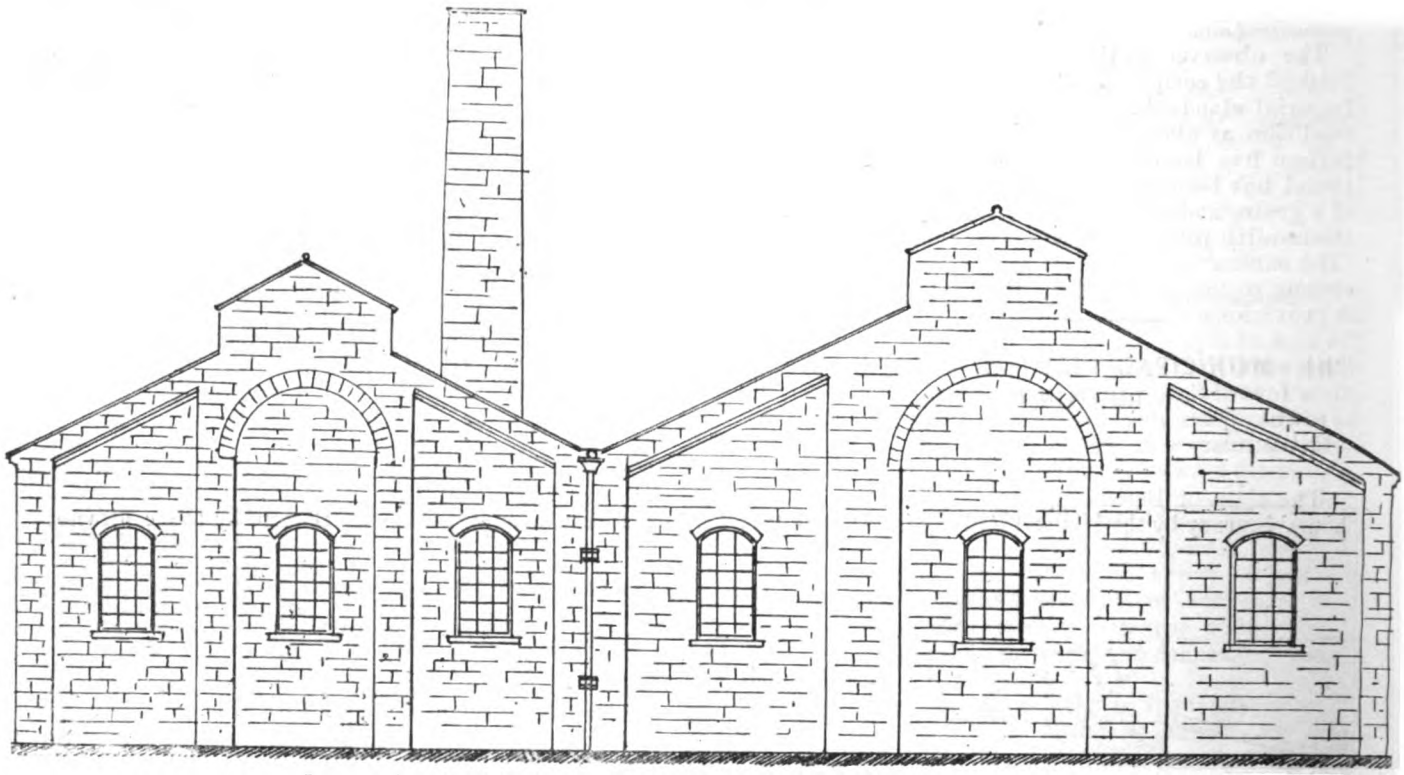
electric light would enable the Town Council to pay for many other improvements they had made, and it was due to Mr. Alderman Lowe that the electric light enterprise had reached its present position.

they had some discretion about them because they had selected the same contractors.

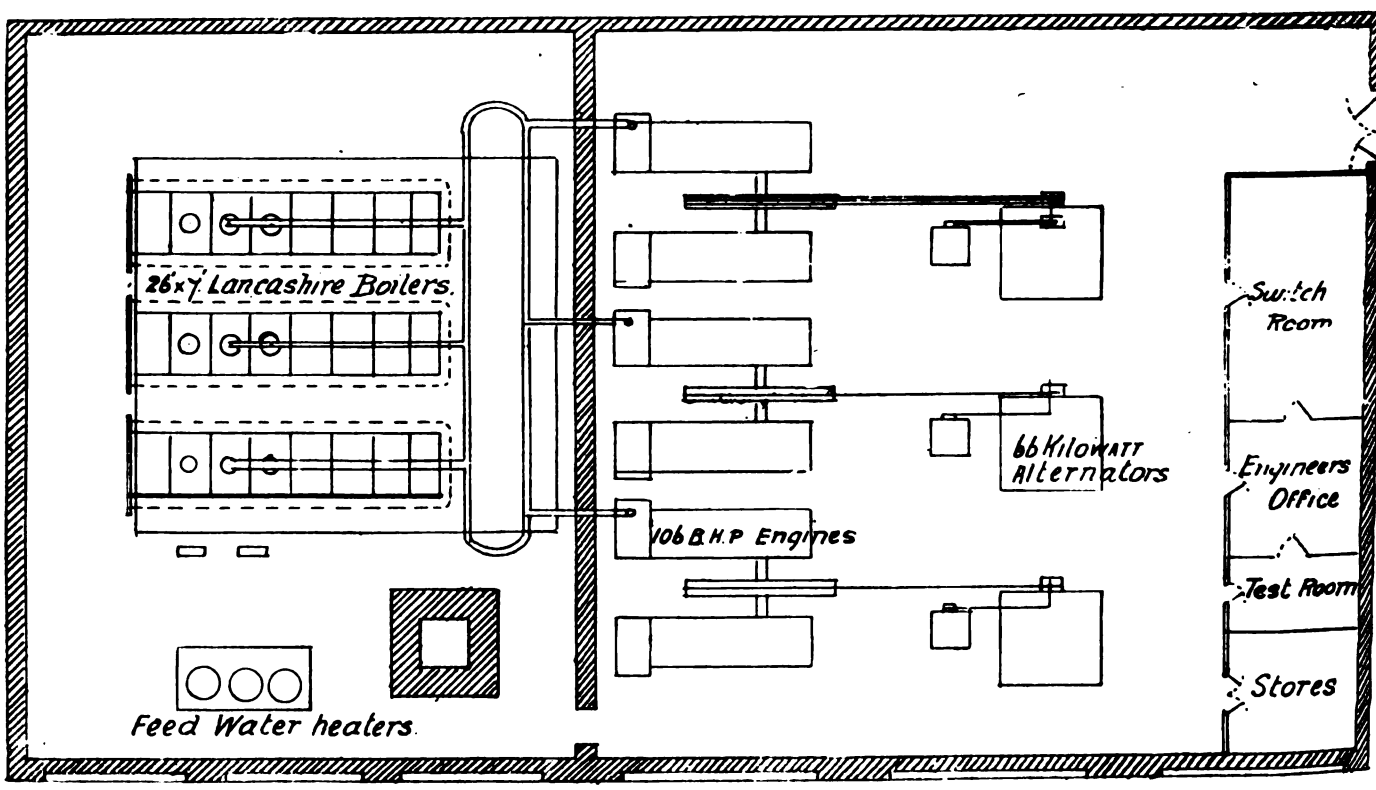
Mr. Councillor MORRIS responded to the toast in some well-chosen remarks.



Burton-on-Trent Central Station—End Elevation of Boiler and Engine Houses, facing roadway.

Mr. Alderman T. B. LOWE (the chairman of the Electric Lighting Committee) responded to the toast in the absence of the Mayor (Mr. Alderman J. A. Coxon) through illness. He said that the Corporation was perfectly free from jobbery, and that he remembered when gas was made first

Mr. Alderman LOWE, in toasting "The Contractors," observed that the Corporation had concluded that their interests would be well placed in their hands, and that the Council were fortunate in having as their engineer Mr. Ramsden, the engineer to the gasworks.



Burton-on-Trent Central Station—Plan of Boiler, Engine, and Dynamo Rooms.

in Burton and sold at 10s. 6d. per thousand. Local self-government was the highest form of government.

The MAYOR OF COVENTRY, in proposing "The Town and Trade of Burton," said that the step taken by the town in adopting the electric light could not fail to assist the trade in the future. They in Coventry were very careful, but

Mr. H. FOWLER, in replying, said that his firm were originally associated with Mr. Hammond in this contract. The latter's present position was entirely due to the satisfactory work he had carried out as a contractor. After they secured the Burton contract, Mr. Hammond withdrew to a higher sphere, that of consulting, and Messrs. Fowlers

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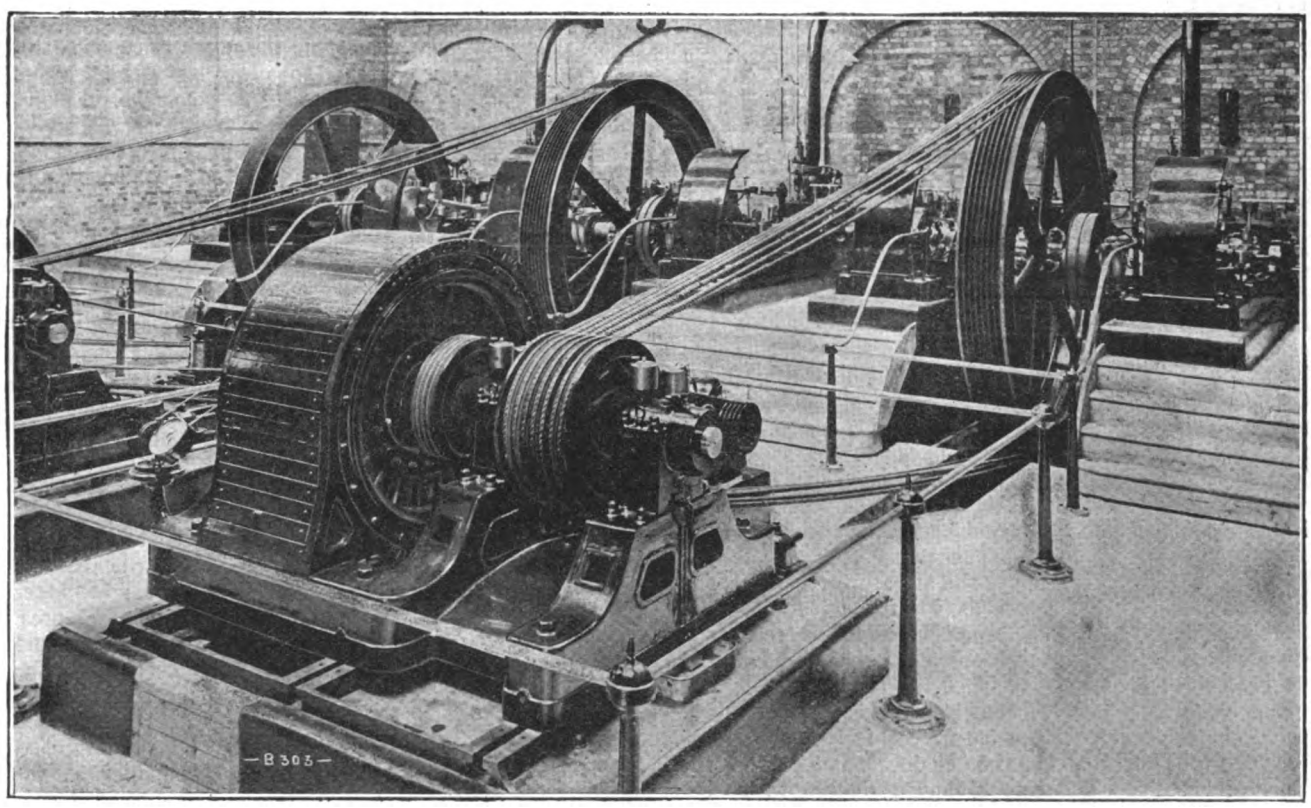
remained. That was why the former's name was not coupled with the toast. To Mr. Daniels was due the credit of designing the engines, and Mr. Hall the electrical portion.

The remaining toasts were "Success to Electricity," given by Mr. Alderman HARRISON, and replied to by Mr. HAMMOND; "The Visitors," proposed by Mr. Councillor GRAHAM, and responded to by Colonel HILL; "The Chairman," by Mr. Councillor F. THOMPSON, and replied to by Mr. FOWLER; and "The Engineering Press," by Mr. THOMPSON, and very ably responded to by Mr. W. WORBY BEAUMONT.

GENERAL REMARKS.

The central station, which was inspected by the visitors previous to the dinner taking place, has been erected under the provisional order obtained by the Corporation in 1890. The area of supply included in the order embraces the whole of the municipal borough, but the compulsory order includes only a few of the principal streets in and about the centre of the town. The generating station is situated adjoining the north boundary wall of the gasworks, on a plot of land



Burton-on-Trent Central Station—Internal View of Engine and Dynamo Room.

some three-quarters of an acre in extent, that has been leased by the Corporation from the Marquis of Anglesey for 99 years. The site was selected partly because no very suitable piece of land was obtainable in a more central position, and partly owing to the fact that by having the generating station adjoining the gasworks, working expenses would be somewhat reduced, and great facilities offered for the supply of fuel, removal of ashes, etc. The buildings for the generating station, views of which are annexed, were designed, and the drawings prepared at the gasworks, under the superintendence of Mr. Ramsden, the Corporation gas engineer, who was assisted by Mr. H. Waring. The buildings comprise boiler-house 60ft. long by 45ft. wide by 24ft. high to eaves, and engine-house 60ft. long by 63ft. wide by 24ft. high to eaves. Both of these are substantial plain brick buildings.

The system adopted is the high-pressure (2,000 volts) alternating-current transformer system of supply at constant pressure to transformers fixed in suitable positions in street boxes on the route of the high-tension mains, feeding on to the low-pressure (100 volts) cables for private supply. At present mains are laid and a supply of current is available in the following streets: Wetmore-road, High-street, Market-place, Bank-square, Station-street, Station-bridge, Borough-road, St. Paul's-street, E., and St. Paul's-square, the latter being 3,000 yards distant from the generating station.

THE BOILER-HOUSE.

The boiler-house, the dimensions of which are given above, contains three Lancashire boilers, each 26ft. long by 7ft. diameter, constructed for a working pressure of 100lb. per square inch, with ample space for further boilers when required. The principal feature of the boilers, which are worked under forced draught by means of a separate engine, is the fact that the furnaces are fed practically with the refuse from the gasworks. The fuel comprises a mixture in the proportions of two parts of coke breeze, one of pan ash from the retorts, and one of very small coal. A large portion of these has hitherto been worthless at the gasworks, but now it comes in handy and cheap for the boiler furnaces. The cheapness of the fuel will be readily understood when it is mentioned that it costs less than 3s. a ton, so that considerable economy in fuel is anticipated. Three feed-water heaters are provided for the utilisation of the exhaust steam, whilst the water supply is pumped from a branch of the Trent adjoining the works.

A very simple arrangement of steam, exhaust, auxiliary steam, and drain pipes, including all the requisite pipes to and from the engines, feed-water heaters, pumps, tanks, etc., has been worked out. An auxiliary steam-pipe is provided for supplying the pumps and stoker engine independently of the main steam-pipe. The donkey pumps for feeding the boilers are of the duplex ram type, each of sufficient capacity to feed two boilers when working at their full power. The main steam-pipes are connected up in the form of a ring, to which both boiler and engine branches are connected, thus providing two ways by which the engines can be supplied with steam, so guarding against the possibility of breakdown of the running of the engines, should any portion of the steam range give way or be under repair. These pipes are provided with a suitable number of stop-valves placed between each engine and boiler, and are carried on brackets fixed to the wall of engine-house. The branch pipes to the engines are of wrought iron, fitted with wrought-iron flanges. The exhaust-pipes lead off from under the low-pressure cylinders, and a stop-valve is provided to each engine exhaust to shut it off from the main

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exhaust-pipe. Valves are arranged so that the whole or part of the exhaust steam can be turned through the heaters or direct into the atmosphere through the roof of the boiler-house.

The Engines.

There are laid down three Fowler 125-h.p. engines, which drive by ropes three 66-kilowatt alternators. The engines are arranged on massive bed-plates raised higher than the floor level. They are of the horizontal, coupled, compound, non-condensing type, the sizes adopted being considered suitable units to work in sections, having regard to the varying load. The speed of the engines is 90 revolutions per minute, and the ordinary working load is 125 i.h.p., at a steam pressure of 95lb. per square inch, but they are capable by increasing the steam pressure of giving a much larger output. The chief dimensions of the engine are: high-pressure cylinder, 14in. diameter; low-pressure cylinder, 24in. diameter; stroke, 24in. Two of the principal features of the engines are the arrangements adopted for collecting the waste oil for re-use, and the vertical governors introduced instead of those of the ordinary horizontal type, the former being much more sensitive than the latter.

The Alternators.

The alternators, which are of the "Leeds and London" type, constructed under Hall's patents, have been specially designed for the distribution of alternating currents from central stations, and they are arranged for parallel running. They are of strong mechanical construction, suitable for continuous running, and capable of withstanding rough usage. The shafts are of mild steel running in gunmetal lined with white-metal bearings of large diameter and ample length; oil throwers and waste-oil chambers are provided at each end of the bearing, from which the waste oil is led into tanks in the base-plate of the alternator. The magnets are the rotating part of the alternator, and consist of laminated horse-shoe stampings built up overlapping (alternately) so as to form a complete circle with polar projections. These are bolted solidly together, and secured to the shaft at the boss by means of keys and set-screws. Magnets so constructed give the maximum efficiency for the energy expended in magnetising them owing to the quality of the iron, and being laminated are quite free from eddy currents, which would cause energy to be dissipated in them if they were solid, due to the armature reaction. The armature being stationary lends itself for sectional construction, and as this is built up of laminated charcoal iron sheets with short polar projections, each section, having its own armature coil securely attached, can readily be removed for inspection or repairs without interfering with any other part of the machine. The armature coil is insulated from the armature core; this is then again insulated from the frame of the machine, thus giving a double insulation between the conductor and frame or earth. The main terminals are mounted upon porcelain insulators, and enclosed in the wood lagging, and this renders it impossible for personal contact with the high-pressure conductors. The alternators are separately excited by small continuous-current dynamos driven back by means of a pulley fixed on the alternator shaft. The low current density at which these machines are constructed will readily permit of their being considerably overloaded with safety during the short period of maximum demand.

The Switch-room.

The switch-room is equipped with the most modern appliances for controlling the circuits and maintaining the voltage on the lamps free from variation. The switch-board is arranged according to the Lowrie-Hall patents, and is similar to that in the West Brompton and other works. It provides in the simplest manner for the putting on and off of either of the circuits and dynamos, either circuit and any dynamo being interchangeable. It is also fitted with a synchronising board, necessary when alternators are run in parallel, or when the load is changed over from one alternator to the other. The plant is, however, designed so that it may be run continuously in parallel. The trenches containing the cables lead into the switch-room at the back of the switchboard, where ample space is provided in which the connections from cables to switches or cross-connections on the switchboard can be easily and safely inspected. The connections at the back of the switchboard are all suitably labelled, so that the attendant in charge has always before him a means of tracing the connections. The switchboard has been designed to deal with two circuits, and is complete with all the necessary instruments for showing current or pressure for switching exciters on or off, and for regulating the voltage so as to preserve a constant potential at the lamp terminals of the consumer. The test-room is equipped with a Thomson standard voltmeter, Siemens dynamometers, a Wheatstone bridge, and a Thomson reflecting galvanometer, etc.

The Distributing System.

The distribution is effected by means of stranded copper single cables, insulated with vulcanised indiarubber and laid in a specially designed system of pipes, combined with service and junction boxes. Each junction-box has a loose cover, held in position by a wrought-iron clamp. The culvert connection from the box to the consumer is made of wrought-iron pipe. The surface boxes are in all cases placed at the corners of the roads, and in the case of a long straight run they are placed at distances of 80 to 100 yards apart. The surface boxes are made in two parts, the bottom part being permanent and the upper part, with the cover, being adjustable, so as to allow its surface to be raised or lowered as the road-level may vary, the lid being filled in with wood, macadam, or pavement, according to the construction of the road. From the surface boxes the cables can be drawn in or out as required. When passing round corners the cable is placed on a revolving drum, which prevents the possibility of abrasion. The jointing of branch cables for consumers' premises is effected by cutting away part of the insulation of the main cable, which consists of indiarubber, in the junction or surface boxes, and soldering the copper conductor to the conductor of the branch cable. The joint is then lapped over with rubber to the full thickness of the original insulation, and vulcanised on the spot, and the cable well taped and mechanically protected. This makes the insulation of the joint practically equal to that of the cable itself.

The transformers are of the Lowrie-Hall type, and were made by Messrs. John Fowler and Co. They are solidly built, are thoroughly insulated in order to avoid any chance of "burning up," and are placed about 220 yards apart in cast-iron waterproof chambers, with side wings or boxes cast upon them, so that the pipes conveying the high-pressure cables at 2,000 volts pass in on one side, and those containing the low-pressure cables, at 100 volts, on the other side, the cables themselves passing through the stuffing-boxes into the watertight chamber. The principle of the stuffing-box is the compression of a substantial vulcanised indiarubber ring of the same quality as the cable itself. In the interior of the box is placed a converter, together with high and low pressure fuses, earthing device, and high and low pressure switches. The latter are double-pole double break, and are connected together by an insulated distance-piece, so that both switches are turned off at the same moment, thus preventing any sparking, whatever load may be switched off. In order to take up any original moisture which may have been in the air and fittings in the box, a jar of caustic potash is placed to absorb this moisture, and once dry it remains so until any future date when the box is reopened.

The capacity of the station is 6,000 8-c.p. lamps fixed, with one set of plant in reserve, but ample space is available for extending the station buildings in one direction, so as to accommodate plant for the electric lighting of practically every house in the town. At present the equivalent of 2,000 8-c.p. lamps is connected to the low-pressure mains, and considering that the supply of current only commenced on 23rd February last, this may be regarded as a fair appreciation of the inhabitants for the electric light. For the moment those people who have not already taken up a supply are waiting until the approach of winter before doing so. It must not be forgotten that the combination of the gas and electricity works on practically the same site and management—Mr. F. L. Ramsden being the borough electrical engineer—is a step in the right direction, and one which is worthy of emulation.

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POLYMORPHIC GENERATORS.

M. E. Hospitalier, in a lengthy article in the current issue of *L'Industrie Electrique*, deals with polymorphic generators and transformers of electrical energy. He terms polymorphic generators those machines which can produce successively or simultaneously electrical energy in various forms, and polymorphic transformers those apparatus which receive energy in one form and give it out again in one or several different forms. The author then reviews the principal types of these machines and apparatus, and gives the following classification.

POLYMORPHIC GENERATORS.

Direct and alternating currents	Pixii and Clarke's first machines. Small magnetos and demonstration dynamos Helios dynamo-motor-transformer (1887). E. Thomson's mining dynamo (1890).
Continuous and alternating diphase currents	Schuckert dynamos (1891). Westinghouse dynamo for Rochester (1893). Eclairage Electrique Company's dynamos (1894).
Continuous and alternating triphase currents	Ducretet and Cadiot demonstration dynamo.
Alternating, simple, and diphase currents	Tesla-Westinghouse dynamos (1893). Creusot twin dynamos (1893).
Alternating, simple, and triphase currents	Triphase-current dynamos.

POLYMORPHIC TRANSFORMERS.

Form of current to be transformed.	Form of current as transformed.	Inventors, apparatus, and applications.
Continuous currents	Alternating simple currents	Solignac undulator (1877). Helios transformer (1887). E. Thomson rail welder (1893).
	Alternating diphase currents	Schuckert apparatus (1891).
	Alternating diphase currents	Dolivo-Dobrowolsky apparatus (1891). Hutin and Leblanc apparatus (1893).
Simple alternating currents	Continuous currents	Gaulard commutator (1884). Lane Fox commutator (1887). Pollak commutator (1893). Helios transformer (1887).
	Alternating diphase currents	Two circuits with different self-induction. Tesla (1887 Self-induction and mutual induction. Ferraris (1888). Self-induction and capacity. Boucherot (1890). Hutin and Leblanc (1891). Motor with closed asynchronous armature with secondary inductor coils. Potier (1894).
	Alternating triphase currents.	Motor with closed asynchronous armature with secondary inductor coils. Potier (1894).
Alternating diphase currents	Continuous currents	Schuckert (1891). Budapest central station (1893).
	Simple alternating currents	No special apparatus. Take separate branches from each of the two circuits.
	Alternating triphase currents.	Scott (1894). Two induction transformers.
Alternating triphase currents.	Continuous currents	Lahmeyer's motor-transformer (1893). Hutin and Leblanc (1893).
	Simple alternating currents	No special apparatus.
	Alternating diphase currents.	Scott (1893).

THE VENTILATION OF BUILDINGS BY ELECTRICITY.

The subject of efficiently ventilating public and other buildings is of paramount importance, and has received a certain amount of consideration at the hands of electrical engineers in the introduction of electrically-driven fans. A method applicable to practically every system of ventilation has, however, not hitherto been brought out; but Messrs. Hodges and Todd have now devised a means intended to ventilate buildings by electrically controlling the air-shafts automatically at any desired temperature, and to keep the temperature of rooms constant. It is termed the Westbrooke thermo-electric ventilating apparatus, and a general view of it is given in Fig. 1, and a diagram of connections in Fig. 2. The important features of the apparatus are that it can be easily connected to any existing form of ventilator, and that it is cheap and reliable, and entirely independent of personal supervision.

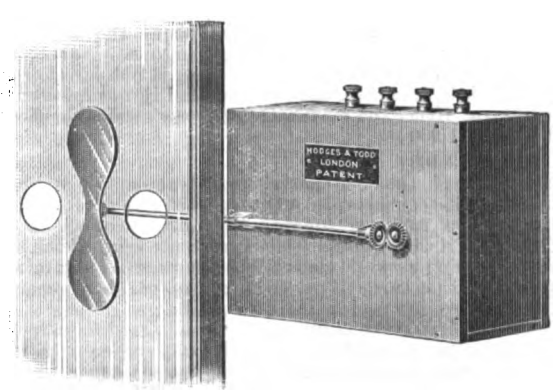

FIG. 1.

As will be seen by the illustration, the apparatus is compact and occupies very little room. It consists of one or more air-valves electrically controlled by means of a thermostat or thermometer adjustable to certain predetermined degrees of heat or cold. The action is as follows: Let us assume that the heat of the building or room is required to be kept, say, between 65deg. and 75deg. F. An electromagnet, M, is placed in circuit with a battery, B, and a revolving drum, D, which is rotated by a strong spring, and makes circuit between the bottom contact, A, and each of the two top contacts, A_2 and A_3, alternately through the thermometer or thermostat. On the temperature rising to 75deg. the contact is made, and the circuit is completed through A_2. The electro-magnet attracts the armature and allows the drum to rotate a quarter of a revolution; this opens the ventilators and cools the room. As soon as the drum begins to revolve, the circuit is broken and the battery is not again put into use until the temperature falls to the 65deg., when contact is again made, and the circuit completed through the other spring, A_3; the drum then rotates and closes the ventilator. This action is repeated every time either limit is reached.

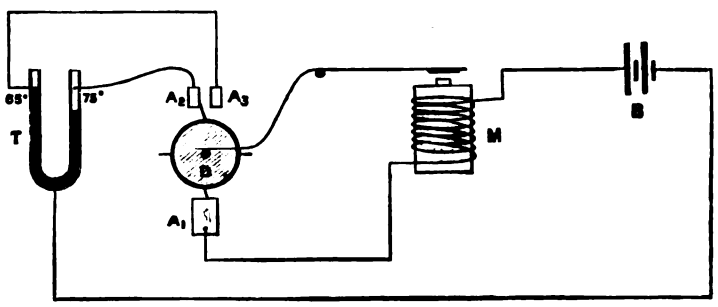

FIG. 2.

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If used in connection with a thermostat instead of a thermometer, the apparatus can be regulated so as to work with a variation of 2deg. of temperature; and the electrical circuit being only made momentary, a very minute amount of current is used, being considerably less than that required to ring an ordinary electric bell.

This system of ventilation should prove of value for use in hospitals, conservatories, and public buildings where it is necessary to have the temperature kept within certain limits. The apparatus can be fitted to any existing air-shafts. It can also be applied to the working of ventilating fans for starting and stopping at certain temperatures.

SOME REMARKS ON POWER DISTRIBUTION BY ELECTRICITY, WATER, AND GAS.*

BY ED. C. DE SEGUNDO.

For some time past the author has been struck by the great discrepancy between theory and practice that must exist in the working of electric generating plant in central supply stations where steam is used. Observation and experience alike have served to accentuate the inefficiency of electric generating plant, and some rough comparisons made with other modes of producing and distributing power have led him to go into the matter more carefully, and when invited by Mr. Worby Beaumont to contribute a paper to your society, he not only felt honoured at such a request, but was glad of an opportunity of bringing this matter before engineers for discussion. Such a subject as the distribution of power admits of practically endless elaboration. Moreover, nothing can be gained by generalisations from the results of existing or proposed distributing systems. The proper value of each system is entirely conditioned by the initial form in which energy is available, and by the final form in which it is required. As one of the most important developments of modern engineering lies in the application of electrical energy to lighting, this latter will be considered as the final required form of energy, and coal will be taken as the initial form in which energy is available. These conditions apply to nearly all large towns. In the following lines, the author proposes briefly to consider: (1) the efficiency of electric generating plant in central stations at the present day; (2) the efficiency of power-producing plant in hydraulic power stations; (3) the efficiency of gas-engines for production of power.

Efficiency of Central Stations.

The definitions of efficiency are probably more numerous, even, than those of "load-factor," and no doubt the ingenuity of that class of investigator which seeks to make a labour of investigation is not yet exhausted in the direction of finding out new possible ratios; but in such a paper as this, which is designed more to suggest a line for discussion than to deal with any discoveries or startling novelties, it is well to briefly consider which definition of efficiency is best calculated to serve the purpose of this paper. The efficiency with which the practical engineer has to deal may be expressed—perhaps with brutal matter of fact-ness—as the ratio of what you get to what you pay for. But while such definition expresses the main value of a combination of machines commercially, it is not a convenient ratio for comparison with other similar ratios, because the introduction of market value at once destroys the possibility of bringing each fraction to a common denominator. As the motors that will be considered to-night are all heat machines, the author proposes to base his comparisons upon the ratio of the thermal equivalent of useful work available for commercial purposes to the calorific value of the fuel burnt per hour. Such considerations as the cost of fuel can easily be applied after. This definition, however, is open to the objection that it is not fair. It may be argued that if a heat machine of necessity rejects a large proportion of the heat it receives, it is not just to calculate an estimate of efficiency upon a basis which is impossible of realisation, and that the efficiency should be expressed by the ratio of useful work to maximum possible useful work in that class of heat machine. The author would submit that while such a contention bears the semblance of justification, it should be borne in mind (1) that the fact of a machine necessarily rejecting a large proportion of the heat received cannot be pleaded as a valid reason why such a proportion of heat should be rendered unavailable, (2) that the definition adopted by the author gives an absolute basis for comparison, (3) that as long as the meaning attached to the word efficiency is quite clearly understood it can make no difference to the argument if the actual instead of the ratio of the actual to maximum theoretical efficiency is used, (4) that the latter is merely one of the very numerous definitions of efficiency. A steam-engine is usually accounted an extremely wasteful heat machine, but this is, strictly speaking, not the case. The only way to increase the efficiency of the steam-engine is by lowering the lower limit of temperature, but directly efforts are made in this direction a limit is soon reached beyond which further lowering of the temperature not only ceases to be productive of any good, but is productive of evil. In short, it may be said that all the heat developed in the combustion of fuel is utilised by the steam-engine, either in doing work or in providing the means of doing work or controlling the rate at which work is done. The efficiency of the steam engine and boiler combined is not difficult to determine; it is the ratio of the thermal value of the brake horse-power hour to the calorific value of the fuel consumed per brake horse-power hour.

The efficiency of the gas-engine and its equivalent of steam-boiler requires some investigation. A ton of coal, according to Mr. Emerson Dowson, may be taken to produce 9,500 cubic feet of gas and 1,500lb. of coke, of which about 400lb. will be consumed under the retort. Assuming that coal having a calorific value of 14,000 thermal units per pound is used, and taking the calorific value of coke at 10,000 thermal units, the number of thermal units liberated from the ton of coal is (neglecting heat necessary to raise the mass of coal to the temperature of the retort),

$$2,240 \times 14,000 - 1,500 \times 10,000, \text{ or } 16,360,000 \text{ thermal units.}$$

Of the heat developed by the consumption of the coke under the retort, a large proportion can never be expected to reappear in the gas. But 16,360,000 thermal units have actually disappeared in producing 9,500 cubic feet of gas; hence $\frac{16,360,000}{9,500}$, or 1,722 thermal units should be accounted for per cubic foot of gas.

Prof. Kennedy, Prof. Unwin, and others have made calculations of the calorific value of a cubic foot of gas, the results of which agree fairly. The average calorific value of London gas may be taken as 620 thermal units per cubic foot at 55deg. F., and at a pressure of 14·71b. per square inch; hence the efficiency of the gas generator is $\frac{620}{1,722}$ = about 35 per cent.

The function of a steam-boiler is, in the case of a gas-engine, split up into two—one portion is done at the gasworks, and the remainder in the cylinder of the engine itself. Now about 20 per cent. of the heat given to a gas-engine is turned into indicated power, or in the case of a large-sized engine about 20 per cent. is converted into brake horse-power. Hence the real efficiency of the gas-engine and boiler so to speak is about 7 per cent. The efficiency of a non-condensing steam-engine consuming 2lb. of coal of a calorific value of 14,500 thermal units and working at 80 per cent. mechanical efficiency is 8·72 per cent., so that the total efficiency of one machine is very much the same as that of the other on this basis of argument. But Mr. Dowson claims to produce one brake horse-power hour for 1lb. of anthracite, by using his generator gas. This (taking the calorific value of anthracite at 16,000 thermal units per pound) would correspond to a total efficiency of nearly 20 per cent., an efficiency which the steam engine and boiler can never hope to reach. Although the author desires to consider the two heat machines on the basis of what may be termed the useful efficiency—namely, the ratio of available power or brake power to power equivalent of fuel burnt—still, in the face of so great a difference as the foregoing, it may be of interest to enquire into the reason of the difference, and to do this it is necessary to consider another efficiency—namely, the ratio of heat turned into work in the cylinder to the maximum theoretically possible. The latter quality is expressed by Carnot's law as the ratio of the difference of temperature at which heat is received and rejected to the absolute temperature at which the heat is received. In the case of the steam-engine this ratio is not difficult to determine, because the heat is all received at one temperature and rejected at one temperature. But in the case of the gas-engine this is not so. As mentioned before, part of the function of the boiler, or part of the operation of calling into existence the working fluid whereby heat energy may be transformed into mechanical energy, is performed in the cylinder of the engine itself. This operation cannot be instantaneous, in obedience to physical laws: therefore the heat is received during an appreciable interval of time and at temperatures varying from the temperature of the mixture and the end of compression to the maximum temperature reached by the charge after explosion. In some parts of the cylinder this temperature may, according to Mr. Clerk, be as high as 3,400deg. F. It would appear, however, that most authorities agree upon 2,700deg. F., as about the maximum temperature reached by the charge in gas-engines of all forms. The temperature of the discharged products is not far short of 800deg. F., though, of course, the heat rejected is not rejected at one temperature. Hence the maximum efficiency attainable should be $\frac{2,700 - 800}{3,160} = \frac{1,900}{3,160} = 60$ per cent.

The efficiency of the non-condensing steam-engine cylinder under an admission pressure of 130lb. per square inch, and an exhaust pressure of 20lb. per square inch, would be about 18 per cent. Therefore, if this steam-engine turns 8 per cent. of the heat into work, it is doing as well relatively to its peculiar limitations as the gas-engine that turns 26 per cent. of the total heat received into work. The greater useful efficiency of the gas-engine therefore must be ascribed to the nature of the vehicle used for carrying the heat, and not to the superiority of the gas-engine as a heat machine. The great faults of a gas-engine are (1) the enormous heat lost in the cooling effects of the cylinder jackets (sometimes over 50 per cent. of the total heat), and (2) the high temperature of the exhaust products. It is not within the scope of this paper to even suggest any direction in which the efficiency of the gas-engine might be enhanced, but it is obvious that if the link could be forged between the now disconnected heat chain in the gas-engine cycle, whereby the heat carried away in keeping down the temperature of the cylinder could be usefully expended in some other part of the cyle, the time would not be far distant that Sir Frederick Bramwell has spoken of, when all that remains of the steam-engine would be a working model or two in some obscure museum.

Let us now consider an electric generating plant using steam

* Paper read before the Society of Engineers,

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power. Tests of various portions of electric generating plant are continually being published, which, if they are any criterion of what may be attained in practice, would point to an extremely high efficiency of a generating station as a whole. Any dynamo manufacturer would be much insulted if one were to suggest that his 30-kilowatt machine would not yield a commercial efficiency of over 90 per cent. at anything like full load. The makers of high-speed, non-compound, non-condensing engines claim a mechanical efficiency of something like 90 per cent., with a steam consumption of 18lb. one horse-power hour, or 20lb. per brake horse-power hour, and, moreover, they are always prepare to prove it. Only a few weeks ago Messrs. Siemens published an account of a test of a steam dynamo driven by a Willans engine which resulted in a combined efficiency of 88 per cent. It is also possible to obtain boilers which will evaporate over 12lb. of water from, and at 212deg. F., per pound of good coal. Now, it may be interesting to compare the best possible results based upon such efficiencies. Take a pound of coal whose calorific value is, say, 14,500 thermal units. The author is given to understand that certain boilers in one of the electric generating stations in London evaporate 12·8lb. of water from and at 212deg. per pound of coal. This would correspond to an efficiency of about 75 per cent. Allowing 30 per cent. for loss in transmission and radiation, and 13 per cent. as the highest thermal efficiency of a non-condensing, high-speed steam-engine using 18lb. of water per indicated horse-power hour, this would leave 1,372 thermal units turned into work in the cylinder of the engine. Taking 88 per cent. as the efficiency at which a steam-dynamo was recently described to be capable of working, 1,207 thermal units, or nearly 350 watt-hours, should reappear at the dynamo terminals, and subtracting 10 per cent. for loss in distribution, 315 watt-hours should be paid for by the consumer per pound of coal burnt at the station. This is equivalent to a consumption $\frac{1,000}{350} = 2{\cdot}86$lb. of coal per unit delivered. Were a full load to be maintained at a generating station, this result is what should be realised if the efficiencies claimed for the various factors are trustworthy. But nothing approaching this figure is attained in central-station work, and the whole of the discrepancy is attributable to the influence of a load-factor. In all, eight definitions have been given of the term load-factor. In the considerations under review the author takes the following definition—namely, the ratio of total output to safe maximum output for which the plant is designed. It will be interesting to compare existing practice with the result obtained by assuming efficiencies, etc., which may be reasonably considered to accompany the working of a plant under the ordinary working conditions in England.

In a modern generating station the sizes of the generating units should be so proportioned, and the general arrangements so designed, as to enable a careful man to keep the load on those of his units which are running at a minimum of from 50 to 60 per cent. of full load. This means that on the average the units in work will run at something considerably over half load. From calculations based on the results of actual practice, the author has arrived at 9·5 per cent. as the ratio of thermal equivalent of watts at the dynamo terminals to heat contained in steam supplied which should obtain in a well-regulated central station under ordinary conditions of working in England. Taking, as before, 1lb. of coal of a calorific value of 14,500 thermal units, allowing a boiler efficiency of 70 per cent., 10 per cent. stand-by losses, 9·5 per cent. efficiency of steam dynamo, and 10 per cent. loss in distribution, not more than about 4·4lb. of coal should be consumed per kilowatt-hour, delivered to consumers' terminals. But this figure is not approached in practice, except in one instance by Mr. R. E. Crompton, who states that at Kensington Court he burns 5·5lb. of coal per kilowatt-hour delivered all the year round; but he states that in doing this he forces his boilers, although it is not easy to appreciate the exact meaning of forcing a boiler. Certainly, forcing a boiler usually results in a greater evaporation at a greater consumption per pound of water evaporated, as it is well known that a boiler works most economically at about three-quarter load. Prof. Kennedy has obtained some very good results in the generating stations of the Westminster Electric Supply, but not approaching the figure above arrived at. Mr. Druitt Halpin stated, in the course of some remarks at Nottingham last year, that an analysis of the Board of Trade returns of electric light companies showed an evaporation per pound of coal of only 4lb. of water in the best example and of one or less than one in the worst. This anomaly is difficult to account for; it is usually ascribed to a low load-factor, but this hardly seems reasonable.

Efficiency of Hydraulic Power Stations.

Take, for instance, the working of a station of the London Hydraulic Power Company, The plant consists of boilers, engines, and pumps combined, and accumulators which in practice only act as equalizers. The efficiency of the boilers, the stand-by losses, and the loss by radiation will be about the same as in the case of an electric generating plant—at least, there is no reason why they should be different. But the engines will probably be more economical, because although they run at a diminished speed where the demand on the mains is small, they always work at full load per revolution; of course the engine efficiency is not quite so good at slow speed as at high, but even at a slow speed an engine working at full load per revolution must compare favourably with one doing the same total work in horse-power hours at double or three times the speed. Moreover, at an hydraulic power station it is generally practicable to use triple-expansion condensing engines.

(To be continued.)

THE LONDON CHAMBER OF COMMERCE.

A general meeting of the Electrical Trades Section of this Chamber was held yesterday afternoon at the offices of the Chamber to consider an important and somewhat extensive agenda paper. The proceedings were opened by the chairman of the section, Major Flood Page, who, after the customary routine business, proposed that Mr. Emile Garcke be appointed as chairman of the section during the ensuing two years; this was seconded and carried, a hearty vote of thanks being accorded to Major Flood Page for the valuable services rendered by him to the section during his term of office. Mr. Alexander Siemens was re-elected as deputy chairman, the question of appointing a second such official being left open for the time being. The principal items on the agenda paper dealt with the subjects postponed from the previous meeting, the first being that of road traction. A letter was read from the Board of Trade to the Chamber stating that they had sent on to the Home Office a copy of the letter on this subject addressed by the Chamber to the Board. Major Flood Page informed the section that he had good reason to believe that some difference of opinion existed on the question between the Home Office and the police authorities, and that the action of the latter to some extent appeared precipitate. An application would shortly be made to the police authorities for a license under which an electric vehicle might ply for public hire in the streets, and this would probably lead to a decisive expression from the proper authorities. The section therefore decided to take no immediate action meanwhile, leaving it to the secretary to watch the progress of affairs and at once summon a meeting when necessary, either for considering the question or appointing a small committee for the same purpose in a more convenient fashion. The next question related to the rating of electric supply stations more particularly, and a small committee of five, with power to add to their number, was appointed to consider the somewhat confidential matters involved, and to safeguard as far as possible the interests of supply stations in reference to their assessment for the public rates. The same committee was also requested to consider the position of electric supply stations with regard to alleged nuisances arising therefrom to the public; and although perhaps the real position of these undertakings with reference to actions for damages is based on a legal point—not by any means of unfavourable aspect for the electrical industry—yet it was thought best to refer the matter to this committee as being well qualified to act in the matter from experience of central-station work.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

THE COST OF ELECTRICAL ENERGY.

Sir,—Until the copy of the *Journal* of the Institution of Electrical Engineers which will contain the (so-called) discussion of Mr. Crompton's paper and his summary of the same is issued, I feel myself debarred from dealing with a subject which, in the interests of the profession, I do not think should be allowed to drop.

Each speaker (including myself) has the opportunity of revising the notes of what he said, and the reader of the paper could not be expected to be able to revise the notes of his own final speech until he has had an opportunity of seeing all those revisions in print.

When the number of the *Journal* containing the information in its latest form is out, I trust you will allow me space to show that my friendly criticisms, especially of Table VI., cannot be dismissed in quite as offhand a manner as that assumed by Mr. Crompton on May 24.—Yours, etc.,

C. E. Webber.

27, Chancery-lane, W.C., June 5, 1894.

Laibach.—A scheme for the electric lighting of the town has been prepared by Messrs. Ganz and Co.

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THE

ELECTRICAL ENGINEER.

Published every Friday.

Price Threepence; Post Free, Threepence Halfpenny.

Editorial and Publishing Offices:

139-140, SALISBURY COURT, FLEET STREET, LONDON, E.C.

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TO CORRESPONDENTS.

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THE PERENNIAL BOILER.

Whenever any engineer who may luxuriate in the membership of one or other of the institutions desires to bring himself prominently forward by creating a lively discussion, not only at the institution meetings, but for weeks afterwards in the editorial and correspondence columns of the technical papers, he has only to advocate through thick and thin the merits and advantages of one particular type of steam-engine, boiler, dynamo, or combination of these. Forthwith an avalanche of praise and abuse is poured upon him, from which he emerges, with luck and skill, to take higher rank than ever. Turning, however, from the person to the things, one gets a little tired of the apparently endless dispute as to this or that appliance being the very best of its kind: of course, a thorough ventilation of opinions may be desirable—so long as it is unbiassed, though that is not very often the case, perhaps—but the absurdity of laying down a hard-and-fast rule whereby to regulate the design, say, of an electric lighting station steam plant should be too obvious to require attention by intelligent men.

Yet the question of absolute superiority in, for instance, boiler design and construction is continually cropping up and being argued, as though the real results could be in any way influenced by mere personal opinions or preferences, however much these may alter the facts when stated. One set of engineers swears by the water-tube type; others can see no good in anything but the Lancashire boiler. Both may be right, just as both are certainly wrong in advocating their particular fancy under all conditions. It is neither fair nor wise to compile a formula of design according to which all electric lighting stations are to be carried out. A boiler has to fulfil many conditions for work of this kind: it must not smoke, or the local authorities will have a voice in the matter; it must be a dry and quick steamer, or—what is the same thing to some extent—it must have a large reserve of steam power for the occasions when a sudden demand for light sometimes makes a difference of hundreds of horse-power in the output of the station. Moreover, it should aim at something more than mere high evaporative efficiency—it must have a low fuel cost per unit of water evaporated.

All these conditions may involve such essentials in a boiler that no single type will fully comply with them, but it is not fair to emphasise such qualities as are possessed by one type in order to give it higher rank than others. If, by putting the necessary qualities on a level, it be found that some are contradictory and impossible of attainment in any one design, then surely the proper plan to pursue is to adopt more than one type—to use, say, both water-tube and Lancashire boilers in any electric lighting station, the exact proportions of either being relatively determined by local conditions, such as cost and quality of fuel, importance of smoke prevention, etc. At present, however, the designing engineer appears to be as a rule too much prejudiced in favour of one type to entertain the idea of using any others.

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The wordy battle which has arisen on this point from Mr. Crompton's recent paper presented to the Institution of Electrical Engineers brings forcibly to one's mind the admirable suggestion made by *Punch* at the time of the Berlin Conference. That venerable serio-comic represented Lord Beaconsfield (whose wit was more extensive than his knowledge of French) hesitating at the door of the conference rooms, with his hand on the door knob sufficiently long to ask his fellow-plenipotentiary the proper French expression for "compromise."

We suggest the same idea to boiler-makers and boiler-users: by admitting the good points in each there will be found ample scope for development, without choking off one another until tangible results show the foolishness of such a process.

We make another suggestion, too. The makers of both water-tube and Lancashire boilers would do well if they spent time and energy on adapting their appliances for oil-fuel burning, instead of quarrelling as to their respective demerits. It is more than probable that the use of oil fuel will have a most important effect not only upon the emission of smoke, but also on the rapidity of raising dry steam. Moreover, it avoids almost entirely the troublesome question of mechanical *versus* hand stoking, and gives absolute ease of regulating the air draught. Locomotive and marine boilers have been worked to great advantage by means of oil fuel, and it is more than time that those of the large water-tube and Lancashire stationary types were also experimented with in this direction.

THE PORTSMOUTH MUNICIPAL ELECTRIC LIGHT STATION.

The following description of this station has been furnished us by Messrs. Kincaid, Waller, and Manville. We simply desire to point out that the station was duly opened on Wednesday last. A large number of guests assembled in the dynamo-room, where Alderman Ellis (the chairman of the Light Committee), Prof. Garnett, Mr. Manville, Mr. Ferranti, the Lord Mayor of Dublin, and the Mayor of Portsmouth addressed the guests, and each described some phase of the undertaking. The Lady Mayoress then turned on steam, the gigantic Ferranti armatures revolved, and the incandescent lights around the dynamo-room flashed out. All went merry as the marriage bells. As will be seen from the description, this installation differs somewhat from ordinary lines, but everyone will agree in wishing it success.

In the evening dinner was served in the Town Hall, the Mayor of Portsmouth presiding. Among the large number of guests present may be mentioned the Lord Mayor of Dublin, Mr. Alderman Ellis (the chairman of the Electric Lighting Committee), Dr. Garnett, Mr. E. Manville, Lord Crawford, Messrs. J. Kincaid, F. Ince, S. Z. de Ferranti, G. Verity, S. R. Ellis, J. G. Slatter, and many others. At the close of the proceedings, the Mayor invited the guests to go round the town and inspect the lighting, but as the time was within half an hour of midnight, very few persons made the inspection.

Historical.

The Corporation of Portsmouth applied to the Board of Trade for an electric lighting order under the Electric Lighting Acts, and statutory powers were granted by the Portsmouth Electric Lighting Order of 1890. In 1891 the Council appointed an Electric Lighting Committee to investigate the whole question of the establishment of an electricity supply station; to determine whether it was desirable that the Corporation should establish a works of their own, and if so, to lay before the Council a scheme for carrying out the powers conferred upon them by their lighting order. The members of the committee were: Alderman Emanuel, J.P., mayor; Alderman George Ellis, J.P., chairman; Alderman T. Scott Fosler, J.P., vice-chairman; Alderman Cudlipp; Councillors Beale, Ashdown, Ovens, Dean, Kimber, F. G. Foster, Croucher, Dummer, Fulljames, Dittman, Cooke, Ross, Bamber, and Merritt.

The committee carefully investigated the whole subject, and as a result they presented a report to the Council recommending that the Corporation should itself establish an electricity supply works. An engineer was retained to prepare a detailed scheme for the committee, in which a low-tension scheme was provided for, which would serve a limited area of the borough, and the permission of the Council to expend the sum provided for in this scheme was obtained. Before, however, actually proceeding with the scheme in this form, the committee investigated the working of a number of electric lighting stations in the kingdom, and came to the conclusion that a low-tension scheme would not provide adequately for the requirements of a town extending over such a large area as Portsmouth, and they therefore called in Prof. William Garnett to report to them on the relative merits of a high and low tension system. This gentleman, having thoroughly considered the subject, gave his opinion decidedly in favour of a high-tension system, and at the request of the committee furnished estimates of the capital cost of installing such a system The committee then went before the Council again to obtain its consent to this new scheme, and the Council approving of it authorised the carrying out of the works in accordance therewith, and appointed Prof. William Garnett and Messrs. Waller and Manville to act in this respect as joint engineers to the Corporation. Detail plans of the buildings and specifications of the buildings and machinery were prepared by the engineers, and a large number of tenders were received, out of which it was ultimately decided to accept the following: buildings and building work, T. W. Quick, Southsea; boilers, mechanical stokers, fuel elevator and conveyor, engines, condensers, alternators, electrical apparatus, switchboards, transformers, etc., instruments, etc., Messrs. Yates and Thom, of Blackburn, and Messrs. S. Z. de Ferranti, Limited, of London; turbo-alternator and condenser, C. A. Parsons and Co., Newcastle on-Tyne; insulated conductors, cast-iron conduits, junction-boxes, etc., the International Electric Subway Company, Limited, of London, and W. T. Glover and Co., of London and Manchester.

The Station Buildings.

The plant ultimately decided upon by the committee being in almost all respects novel and original, a detailed description of it will be of some interest. The high-tension alternating-current transformer system giving great latitude for the selection of a site, it was determined to place the generating station in proximity to the harbour, so that the economy of using condensing engines might be obtained; and a suitable position was ultimately found in proximity to the Camber and about 500 yards from the Grammar School, which forms a convenient distributing point from whence the supply mains radiate to Southsea, Portsea, and Landport. The proximity of the site to the Camber further enables coal to be delivered by water practically at the door of the generating station, further securing an important economy. Upon a portion of the site extensive buildings have been erected, in the design of which great care has been exercised so as to provide for a most efficient arrangement of the plant and apparatus in connection therewith, and to allow of future extensions being economically and efficiently carried out. The buildings consist of a boiler, economiser, and engine-house, with a coal store convenient to the boilers, and ample set of offices over the coal-store, and stores, test-rooms, etc., adjoining the engine-house. The ground not yet occupied will ultimately provide a second boiler-house on the other side of the coal-store, which will then be central to the two ranges of boilers; and it is anticipated that the engine-house will be large enough to contain the total plant required to completely utilise the steam produced by the two ranges of boilers. The engine-house is 102ft. 6in. long by 66ft. wide, and 32ft. high to the centre of the roof, and is spanned by a travelling crane which travels the whole engine-house from end to end, and is capable of lifting a weight of at least 10 tons.

Immediately outside the coal-store a chimney shaft has been erected, 120ft. high and 6ft. square inside at the base. The foundations of this chimney are of somewhat original design. It being found that within a few feet of the surface was a bed of shingle, upwards of 22ft. in depth, permeated with water, ordinary foundation, involving close cofferdams and pumping, was considered too expensive an operation, and it was decided to build the chimney upon a concrete "raft." A bed of concrete 20ft. square, and about 6ft. in thickness, bound together in both directions by steel joists, forms this "raft," and distributes the weight of the chimney, so that a pressure of not more than a ton to the square foot is transmitted to the bed of shingle. An important feature in the design of the buildings is the position of the engineer's office. This forms the roof of the economiser-house, and is built in between the walls of the engine-house and boiler-house, and has a cast-iron balcony projecting into each of these houses. The engineer in charge can thus watch the working of the machinery both in the engine-house and boiler-house without the necessity of leaving this room, whilst a staircase from the balconies enables him to get direct into either building. The rooms off the engine-house consist of a large store, the recorder-room, the motor commutator-room, the test-room, and—a not unimportant feature in a building of this kind—a mess-room for the workmen, and a properly fitted lavatory.

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The Boiler-house.

The boiler-house contains a range of five Lancashire boilers fitted with all the most modern appliances for labour saving. The relative merits of the various types of boilers were carefully considered by the engineers, and in the end it was considered that either tubulous boilers of the Babcock and Wilcox type or Lancashire boilers would be the most suitable. Seeing that "Sunny Southsea" and Portsmouth are never visited by fogs, and that, therefore, the demand for steam upon the boilers could be accurately ascertained from hour to hour at any season of the year, it was decided to instal Lancashire boilers, having due regard to their simplicity, excellent evaporative qualities, and small cost of maintenance. The first range of boilers, five in number, are each 7ft. 6in. in internal diameter, and 30ft. in length. They are constructed to withstand a daily working pressure of 160lb. to the square inch, although it is not intended to work them at a pressure exceeding 140lb. to the square inch, the balance between that and the working pressure for which they have been designed being allowed for the drop in pressure that will be required from time to time by the insurance companies as the boilers wear, and which will thus provide for the lapse of a number of years before getting below the economical working pressure for the engines. The boilers are fitted with Vicars mechanical stokers and furnaces, and coal is conveyed to the hoppers of these stokers by a conveyor running across the boiler-house directly over the hoppers. An elevator in the coal-store outside the boiler-house wall raises the coal and delivers it to the conveyor, and the elevator is of sufficient size to deliver coal also to a second conveyor, which will ultimately be installed to serve the second range of five boilers when these are erected. Two small vertical high-pressure engines are provided under the elevator to drive the elevator, conveyor, and mechanical stokers, these engines being in duplicate, so that a breakdown of one may not interfere with the proper working of this gear.

A large damper in the main flue between the economiser and the chimney shaft is connected to a hand-wheel in front of the boilers, so that the draught may be regulated from that end without the stoker leaving his place, and it is hoped that by this complete arrangement for the stoking and regulation of the boilers the minimum of hand-labour may be required for the raising of the steam, and that coal of a cheap quality may be economically and unobjectionably used. The flues behind the boilers are in duplicate, and in one of them the three sections of the economiser is placed, numbering in all 288 heating pipes. The flues are so arranged with dampers that the products of combustion can be either passed through the economiser or through the second flue when the economiser requires cleaning out or repairs, and these two flues are so arranged that they can ultimately be extended to a second chimney shaft that will be erected next the second range of boilers, so that either or both chimneys will serve either or both ranges of boilers. The scrapers on the economiser, and likewise the stirrer in the water-purifier, are driven by Brown alternating-current motors in place of steam-engines. In a small room adjoining the boiler-house are placed the feed pumps. These are not of the ordinary direct-acting type, but consist of vertical simple engines driving three-throw pumps through helical gearing, this arrangement of pumps having the advantage that the engine driving them has a proper cut-off and allows for the economical use of the steam required to drive them, whilst the ability to put out of action any one of the pumps and to alter the speed of the engine gives almost equal range of feed with that obtained with direct-acting pumps. The pumps derive their water supply either direct from the town mains or from a water-storage tank, capable of containing 20,000 gallons of water, erected on the roof of the men's mess-room. The suction pipes are in duplicate, and the feed pipes from the boilers are also completely in duplicate, each boiler being connected to both ranges through separate feed back-pressure valves, and each range is connected to the economiser, so that the water pumped through it can be sent either through the economiser tubes to the boilers, or direct to the boilers. The town water supply in Portsmouth being of exceptional hardness, a water-purifying apparatus has been provided next the storage tank referred to. This has been provided by the Stanhope Water Engineering Company, and is of sufficient size to purify 2,000 gallons of water per hour.

The Steam-pipes.

The engineers have bestowed special care in the arrangement and construction of the steam-pipe connections between the boilers and the engines, considering that immunity from breakdowns is to a large extent dependent thereon, and in place of arranging the steam-pipes in a ring main, two entirely separate ranges of main and branch steam-pipes have been provided, so that each engine has two separate connections to the boilers. Each boiler is provided with two stand-pipes terminating in stop-valves, each of these stop-valves being connected through 6ft. spring lengths with each of the separate ranges running across the boilers. These main ranges, which are 10in. in internal diameter, are provided each one with a through valve immediately where the ranges pass away from the boilers. The steam-pipes are carried across the economiser flue to a common point within the engine-room, and are then continued one range over the other down the centre of the engine-room. Branch pipes, 5in. in internal diameter, connect each range separately to each engine, and a stop-valve is provided at the root of each branch pipe where it joins the main, in addition to the two stop-valves on each engine. This double system of steam connection has been carried out even to the smallest engines employed, so that no portion of the plant is likely to fall short of a supply of steam through accident. A water-separator is inserted in the run of each steam-pipe just before it reaches the engine-room wall, to ensure the steam being freed from water before reaching the engines, and at the extreme end of the steam-pipes water-catchers are provided to receive the condensed water therefrom, and both the water-catchers and the water-separators are connected with the drains through suitable steam-traps. The greatest care has been exercised in the construction of all the steam-pipes. Both the mains and branches, with the exception of the branches to the pumps and conveyor engines, are made of mild steel plates manufactured by the Steel Company of Scotland. The requisite allowance for expansion and contraction has been provided for without the provision of any expansion joint, the steam-pipes being so arranged that long legs are formed at right angles to the main run of the pipes, these legs having sufficient elasticity in themselves to allow for the elongation of the main pipes.

The Engines and Alternators.

The slow-speed engines and alternators are perhaps the most interesting feature in the installation. In the preliminary stages, when the type of plant to be provided for was being considered by the committee and their engineers, it was wished that slow-speed compound engines, coupled direct to alternators and running at the same speed, might be used, but the estimated cost of such a plant, owing to the very low speed of the alternators, appeared prohibitive. In the specification issued, therefore, coupled compound engines, driving alternators by ropes, were provided for. Messrs. Ferranti, and Yates and Thom, however, in addition to tendering for engines and alternators geared together by ropes, tendered alternatively for the combination of the two at a price which was below the lowest tender received for the machines separately, and the committee recommended the Council to accept this very favourable offer. These machines may perhaps be properly described as engine-alternators, since the alternators are not coupled to the engines, but form an integral portion of them. The engines are of the usual coupled compound type—*i.e.*, the high and low pressure cylinders arranged one at each end of the crankshaft, the fly-wheel being in the centre, and having upon its periphery the field magnets, which revolve inside the stationary armature. Two sets of these engine alternators have been provided in the first instance. The high-pressure cylinder of each engine is 15in. in diameter and the low-pressure 28in. in diameter, the stroke being 36in. These cylinder dimensions were arrived at after mature consideration of the most desirable point in the load of the engine at which to obtain the maximum economy, and seeing that the time during which the engines will ever be working at their full load is but a very small proportion of the time in which a heavy load is on the station, and a still much smaller proportion of the whole 24 hours' running, the engineers thought it desirable to obtain the greatest economy in steam consumption when the engines were running at three-quarters of their normal maximum load. Of course, the engines are of ample size to develop the full output of the alternators, although the work obtained between three-quarters and full load will not be so economical as that obtained at three-quarters load. The valve motions of both high and low pressure cylinders are Messrs. Yates and Thom's improved form of Corliss gear, and the Corliss gear on both cylinders is controlled by a very sensitive form of governor. The governor itself is further provided with a compensator, which delicately readjusts the speed of the engine so as to maintain a practically constant speed under all loads. All the mechanical proportions of the engine are of ample strength for the work required of them, the crankshafts being of a particularly large section—viz., 9in. diameter by 18in. long in the bearings, swelled to 12in. in diameter at the flywheel. The flywheels are 14ft. in diameter, made in halves, and are turned up flat on the periphery and bored in 64 places, arranged equidistant to receive the field magnet cores and pole-pieces. The weight of each fly-wheel is 12 tons, of which the rim alone weighs seven. This weight is exclusive of the weight of the magnets.

Each engine is provided with a separate jet condenser. The air-pumps lie in chambers between the cylinders of the engines, and are worked by rocking beams off the cross-heads of the cylinders. The cylinders are steam-jacketed, and provision has been made for admitting high-pressure steam to the low-pressure cylinder to facilitate starting. The condensers are connected up to an intake pipe 14in. in diameter, which lies in the trench behind the cylinders, and is carried 250 yards to a point in the Camber where tolerably clean sea-water is obtainable. The discharge of the condenser is connected to a discharge pipe 16in. in diameter, also contained in the trench behind the cylinders, which discharges its water into the Camber. In this trench is likewise contained an auxiliary exhaust-pipe, for use when the condensers of any engine may be temporarily out of order, and the engines are so connected to the condensers and to the auxiliary exhaust-pipe that either may be used for receiving the exhaust steam at will. The engines are completely equipped with indicating gear, lubricators on the most modern principle are provided, and the working parts are railed in.

There are many points of novelty in connection with the design and construction of the alternators. As before mentioned, the flywheels of the engines contain upon them the field magnets with their coils. The magnets are 64 in number, and consist of a wrought-iron core, 9½in. long by 5in. in dinmeter, with pole-pieces formed at their outer ends the full width of the armatures. The cores are bolted through the periphery of the flywheel, and are securely fastened on the inner side. Each magnet core is wound with flat copper strip 1⅛in. wide by ¼in. thick, wound in one length into a spiral in a special machine, one side of the strip being covered with shellaced paper. The spiral is compressed

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over a vulcanised fibre, and finished off with vulcanised fibre, cheeks top and bottom, each bobbin so formed being slipped over the magnet core and securely fastened thereto before the core is placed in position on the flywheel. The insulation on the winding of copper strip being out of sight, the magnet windings present to view only bare copper. The section of the copper strip in the winding is such that the difference of potential used to excite the magnets when coupled up never exceeds 46 volts. It will therefore be seen that the flywheel might be washed down from a hose whilst excited without interfering with its insulation to such an extent as to appreciably affect the excitation of the field magnets. Round the flywheel stands the frame which contains the armature sections. The frame is 16ft. 8in. external diameter, and 17in. wide, of cast iron, and made in four pieces bolted together by internal flanges, and having projecting feet which rest on two base-plates for supporting the armature frame in position. The frame is a moulded U section turned on its inside faces, and into the annular recess so formed are fitted segmental blocks made up of wrought-iron stampings, thus forming a continuous wrought-iron armature core round the field magnets. Each wrought-iron laminated block is pierced with seven slot holes from side to side, and is fitted at each side with a gunmetal box having corresponding holes and provided with lids. These boxes and segments are bolted up together in one solid block by means of manganese bronze bolts passing through two of the above-mentioned slot holes, which also keys the whole firmly together. The four holes furthest from the centres of the segmental blocks are fitted with mica tubes, and through these the armature wire is wound, the ends of the coils resting entirely within the bronze boxes. These boxes are run in solid with insulating composition, and then have the lids screwed on. Every part of the armature is, therefore, encased in and protected by metal, no insulation even being visible. Probably no more substantial and endurable alternator than those above described has yet been built. The impossibility of affecting the field magnet windings by water or in any way breaking down their insulation, the complete encasing of the armature windings so that these are not exposed to any external injury or to the influence of damp or dirt, the great ease with which an armature section can be rewound in position should its insulation fail, and the corresponding ease with which a complete armature section with its winding can be removed from the frame and replaced with a complete spare section, are points which the designers hope will commend themselves to every engineer.

There being no losses due to mechanical friction, the electrical efficiency of the alternator is the commercial efficiency of the whole machine. The maximum current required for exciting the fields is under 2½ per cent., the losses due to resistance in the armature coils is 1 per cent., and the losses due to hysteresis 1¾ per cent. It was at first contemplated mounting the exciter on the crankshaft of the engine in the same way as the alternator fields, but the difficulty of effecting repairs to the armature of the exciter induced the engineers to arrange for separate exciters to be provided, which stand at the outside edge of the alternator armature frame, and are driven by ropes off a pulley on the engine crankshaft. These engine alternators have, it is claimed, even greater advantages, from an efficiency point of view than dynamos coupled direct to either low or high speed engines, since the only bearings are the two main bearings peculiar to engines of this type, and there are no extra bearings in which further frictional losses may be sustained. It will therefore, for the first time in this country, be possible to compare the total efficiency of an engine dynamo of this class with direct-coupled plant of the other types that have been for so long in use here. Two of these engine alternators are at present at work at the central station, placed back-to-back across the width of the engine-room, as will be seen from the plan and section, and the station is capable of containing some 10 such sets banked in the same manner. The output of each of these engine alternators, according to the contract, is 212 kilowatts, but it is anticipated that an output of 300 kilowatts can be obtained from them with safety.

The committee determined that they would try with these, the slowest-speed direct-coupled alternators in the country, a type of alternator of exactly the opposite description—viz., Mr. Parsons's turbo-alternator, and side by side with these large slow-speed machines has been erected one of these turbo-alternators. In general construction it is of the same description as those that have been provided for the Scarborough and Cambridge electric supply stations. Its chief point of difference is the comparatively slow speed at which it runs. It is constructed to give a full output of 150 kilowatts at 3,000 revolutions per minute, and, of course, as in the case of the larger machines, its periodicity is 50 complete phases per second. An independent condenser is provided for it, the air-pump being of the tandem compound type and is driven by a vertical tandem compound engine mounted directly over the pump. Both the turbo-alternator and the condenser engine are connected, in the same way as the larger engines, with the two independent main ranges of steam-pipes.

The Main Switchboard.

In the centre of the engine-house, directly under the balcony outside the engineer's office, is erected the switch platform with the main switchboard. This main switchboard has been designed to be of as simple a form as possible, and is very similar to the distributing switchboard used at the sub-stations of the London Electric Supply Corporation and in the generating station at Havre. The framework is of slate construction, and is arranged with horizontal and vertical slabs, so that each switch and each cut-out is contained within a separate compartment. All the current-carrying parts are mounted upon sulphur insulators. The current from the armatures of the alternators is brought on both sides to circular omnibus bars, these omnibus bars being cut into sections, which can be joined up continuously by removable switches on the insulated side and by links on the "earth" side. The current is fed into the omnibus bar on the insulated side through single-pole switches of very strong construction. The synchronising, as well as the joining into circuit of each alternator, is performed by the same switch, a subsidiary contact-piece being provided in the path of the switch before it reaches its main contact, this subsidiary contact being in connection with the synchronising transformers and their indicating voltmeter. The switchboard attendant, therefore, in placing a new alternator into circuit first of all puts his switch half on, until the new machine synchronises with those already running, and when this happens put it over into its main contact. Fusible cut-outs of Ferranti's "dipping" pattern are provided immediately where each dynamo connection reaches the switchboard and immediately where each circuit leaves the main switchboard. These cut-outs consist of an earthenware pot divided into two long compartments by an earthenware partition in the centre. These compartments are filled with oil, and the current passes between two brass springs, one in each compartment, through a thin copper wire fastened over the central partition. The springs are prevented from dipping themselves beneath the oil by the copper wire resting on the partition, but when this wire is fused through excess of current these springs immediately dip themselves beneath the oil, thus effectually extinguishing the arc. An ammeter is provided on each dynamo circuit and on each main circuit, and two voltmeters with large dials and transformers are placed over the switchboard to indicate the E.M F. of the circuits. The circular divided omnibus bar enables all the dynamos to be run in parallel on all the circuits, or any single dynamo to be run on any circuit. Six dynamo switches are provided and six circuit switches. The regulating switches for controlling the E.M.F. at the terminals of the generators stand on the platform in front of the main switchboard. They consist of resistance coils placed as a shunt to the fields of each exciter, the E.M.F. of the exciting current being thus reduced or increased according to the extent to which the field is shunted. One of these switches is provided in connection with each exciter, and the resistance and switch, being arranged in the shape of a standard on the switch platform with a hand-wheel at the top, forms a neat and effective arrangement.

The engineers considering it important that a record should be kept, not only of the current output of the station on private lighting circuits, but of the pressure from moment to moment at which that current output is being provided, an elaborate recorder has been constructed for the purpose by Messrs. Nalder Brothers. It is provided for six circuits, and registers both the E.M.F. and intensity of the current passing to each circuit. A clock of good construction drives a line of shafting, over which the recording papers pass and are propelled. The papers move at the rate of one eighth of an inch per minute, and therefore show easily even momentary fluctuations in E.M F. The recorder is mounted upon the "earth" side of the system just before the circuits are connected with "earth," and is therefore perfectly safe for handling by the attendants in the station.

Public Lighting.

All the principal streets are lighted by electricity, and the arrangements, both in producing the current for the public lighting, and in utilising it, are novel. It has heretofore been the practice to run arc lamps used for public lighting in towns during all the hours of darkness. Obviously, there is no need for this, a good light only being required till midnight, and a much smaller light being sufficient from that time until dawn. The engineers, therefore, recommended the Corporation to have their arc lamp-posts fitted with two 32-c.p. incandescent lamps in addition to the arc lamp. The incandescent lamps are run in parallel off the low-tension distribution mains referred to hereafter, whilst the arc lamps are run in long series off the arc lighting mains, also described hereafter. The connections to the incandescent lamps are made through fusible cut-outs and properly designed switches contained in the base of the lamp-posts. The switches are arranged so that they can be turned from the outside of the lamp-post without opening any door. For the present the incandescent lamps will be switched on at 12 o'clock midnight by hand and extinguished at dawn by the same means, but it is hoped shortly to introduce a clock switch in each lamp-post, which will always close the incandescent circuit at midnight, and will open the circuit again at varying times, according to the season of the year, in the same manner as an alarum clock is set.

The arc lamps are all of the Brockie-Pell double-carbon type arranged to burn upwards of 30 hours without retrimming, and the total number in use at present is 102. In the base of each lamp, in addition to the incandescent lamp switch and cut-out, is an arc light switch, arranged to completely cut the arc lamp out of circuit, and at the same time to connect across the arc lighting mains when this is effected, thus placing a lamp-trimmer out of any possible danger when attending to the lamp whilst the current is on the circuit. A very interesting point in connection with the arc lighting is the method of producing the current. Heretofore it has been the usual practice, in the case where the public lighting is provided in addition to the private lighting, that an entirely separate plant adapted for running the arc lamps in series is used for the production of the current, the plant generally consisting of three or four sets of engines of comparatively small power, say 60 h.p. to 70 h.p., running high-

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tension continuous-current machines—the disadvantages of this arrangement being that the engines, owing to their small size, are not efficient, and that during the greater number of the hours of darkness the private lighting plant is running with practically no load upon it, and, therefore, at a greater disadvantage than would be the case if the public lighting were effected from the same source. Mr. Ferranti being able, at the time this contract was settled, to satisfy the engineers that he had produced a practical motor commutator commutating alternating currents into direct ones, it was settled by the committee to adopt this method of supplying current to the arc lamps, and to thus keep a load on the private lighting system all night long. The motor commutator consists essentially of a synchronous self-starting motor, the fields of which are excited by its own commutated current. This motor carries at each end of its spindle a commutator, the alternate sections of which are joined together in parallel, and each of the two groups of sections so formed are joined in series to the two groups of sections of the commutator at the other end of the spindle, this arrangement enabling a double break to be provided at the moment of commutation. The sections of the commutator are separated from each other on the periphery by air breaks, and the body of the commutator, which is hollow, is ingeniously arranged so that a current of air is fanned outwards, between the sections of the commutator as it revolves, the result being that the sparking at the commutator when in action is no greater and of no more destructive effect than that seen at the commutator of the well-known types of arc lighting dynamos.

The equipment of the generating station is completed by the addition of a very complete test-room, in which is placed all the standard instruments from which the various instruments on the switchboards are from time to time calibrated, and also the apparatus requisite for ascertaining with great accuracy the insulation condition of the mains from time to time. Most of these have been manufactured by Messrs. Nalder Bros. and Co. A special piece of apparatus has been provided in this room for the calibration of the meters. It consists of a transformer, the primary of which is fed at 100 volts from the local lighting circuit in the station, and the secondary of which is arranged on several sets of terminals, to give a difference of potential from ten to two volts, and further adjustment of this difference of potential is obtained by the adjustment of the core within the transformer. This transformer is connected up to a divided circular omnibus bar connected across by links, and each section of the bar is provided with plug holes, by means of which a meter may be inserted in series with the remainder of the bar, the link being withdrawn after the meter is inserted. Thus a number of meters can be placed in series with each other, and the current through all of them adjusted with the greatest of ease by shifting the connections of the omnibus bar to the various terminals on the transformer, and finally adjusting by moving the core.

The Method of Distribution.

In designing the system of distribution, the engineers gave all consideration to overcoming, as far as possible, the losses inherent in alternating-current transformer systems. The placing of a separate transformer in each building to be lighted was discarded by them owing to its great inefficiency, and they ultimately had to decide between the grouping of transformers in banks in distributing-chambers, at some distance from each other, and the use of a three-wire system for conveying a low-tension current to the consumers' premises, or the placing of separate transformers in boxes beneath the street surface at frequent intervals, feeding into a low-tension two-wire system. Due consideration was given to both these systems, and the greater flexibility of the latter finally decided them to adopt it. The sizes of the low-tension distribution mains have been so arranged that when fully loaded the transformer-boxes shall not be nearer to each other than 300 yard centres; and to further ensure a good efficiency from the transformers the majority of them have been fitted with hand switches, operated through a hole in the street cover, and so arranged that the connections of the transformers can be altered at different seasons of the year, and even daily if found desirable, so that they may either give their maximum efficiency at full load or at third load; and the section of conductor on the transformer is so ample that even if by accident a transformer be switched down to a full efficiency at third load, and left so when full load is on the transformer, no danger of overheating is incurred by the transformer, the only effect produced being an unreasonable drop in volts on the main supplying the consumers nearest that particular transformer. The boxes containing the transformers are of cast iron, and are placed in brick chambers constructed beneath the pavement-level. The space occupied by the transformer proper is entirely filled in with oil, and an upper compartment contains the high-tension fusible cut-out, the switch before referred to, and the Cardew earthing device. The box is then covered in with an airtight cover, and the conductors are led into the box through air and water tight glands, and a second cover is provided to the brick chamber on the street-level covering in the whole of the gear.

Three separate sets of conductors have had to be provided: (1) high-tension feeders to supply the primary windings of the various transformers, (2) low-tension distribution wires receiving the low-tension current from the transformers and distributing it to the premises of the consumers, and (3) high-tension arc lighting mains connecting the arc lamps in series of about 40 each. The high-tension feeders and the arc lighting mains proceed straight from the generating station, but the low-tension distribution wires are entirely disconnected from the generating station, and are only connected with the transformers which feed into them. Alternative tenders were obtained by the engineers for the committee for the use of either armoured cables laid direct in the earth or unarmoured cables drawn into metallic conduits; and, finally, the joint tender of the International Electric Subway Company, of London, and Messrs. W. T. Glover and Co., of Salford, was accepted for this work, the former supplying the conduit and the latter both high and low tension conductors. The Board of Trade requiring that high and low tension conductors shall be well separated from each other by metallic partitions, the Johnson conduit lends itself admirably to this purpose. Two types of this conduit have been used—one having three ducts, each 2½in. square, side by side; the other having two ducts of the same size side by side. The three-way conduit is principally used wherever there are low-tension distribution wires, whilst the two-way duct is used in streets in which there is no likelihood of a demand for private lighting, but through which the high-tension feeders and arc light conductors have to pass.

The conduit is a cast-iron structure composed of two troughs, one placed upon the other, a groove being cast on the edge of the lower and a tongue on the edge of the upper one, so that when put together they exactly fit. The whole of the cast-iron work is coated with Dr. Angus Smith's preservative solution, which renders it very durable. The conduit is divided into two or three ducts, or compartments, as is desired, by means of iron partitions cast on the bottom trough. The rapidity with which the system can be laid is a most favourable feature. The great advantage offered by this form of conduit is the facility with which any of the conductors can be reached along the length of the conduit. The method of drawing in the cables into the ducts is the same as if these latter were separate cast-iron pipes. At suitable intervals a brick drawing-in box has been constructed, fitted with a road-box cover, and the ends of the conduits protrude through the sides of these chambers. The adoption of this conduit system for the first time on a large scale in England will doubtless prove of considerable interest to engineers who may have to consider the provisions of a group of ducts.

The conductors referred to above are of two types—those for the high-tension feeders and for the arc light cables being concentric, and with indiarubber insulation of the highest quality, tested to 5,000 megohms per mile between the inner and outer conductor; those for the low-tension distribution wires being separate cables instead of concentric, and of a lower insulation resistance. The high-tension feeders run continuously through all the streets at present to be served. A distribution-chamber has been constructed opposite the Grammar School, which forms a central point at which three out of the four high-tension feeder circuits converge, and from this distribution-chamber to the generating station two heavy feeders are laid, to one of which the two lighter of the branch feeders are joined, to the other of which the heavier of the branch feeders is joined. Ultimately, a third feeder will be laid from the generating station to separate the two feeders at present joined to the one heavy feeder, when the density of the lighting justifies this being carried out. Of these three-branch high-tension feeders one is carried nearly the whole distance of the Commercial-road, as far as All Saints' Church, and feeds the Landport district; a second one proceeds along King's-road and Elm-grove, supplying a portion of Southsea; and the third along the Terraces and Palmerston-road and High-street, supplying the remainder of Southsea. The fourth high-tension feeder—*i.e*, that supplying The Hard and Queen-street, serving the district of Portsea, which proceeds in an entirely different direction, is taken direct from the generating station without being carried through the distribution-chamber. The arc light circuits in the same way are carried through the distribution-chamber to the generating station, with the exception of that supplying The Hard and Queen-street, which, as in the case of the high-tension feeder, also proceeds direct from the station. The high-tension feeder being concentric, it was considered inadvisable by the engineers to make any T-joints on to it wherewith to feed into the transformers, and in each case where the high-tension feeder passes a transformer it is cut in two, and the ends led out from the conduit into a high-tension junction-box, and again from the other side of the junction-box into the conduit. Within the junction-box the ends of the two conductors of the concentric cable are made continuous through concentric rings connecting together the respective conductors. These concentric rings are made in sections clamped together, and so arranged that from the two sides of the junction-box unoccupied by the main feeder, branch connections can be taken either to the transformer-box or to a sub-branch feeder proceeding down side streets off the main streets, and any of these branch circuits can be readily disconnected from the high-tension feeder when required, and, as will be seen, the high-tension feeder itself can be broken up into comparatively short lengths for isolating faults and for executing repairs on faulty sections; and to provide against a discontinuance of the supply of electrical energy on any section, excepting the one under repair, the high-tension feeders, as they are extended, in course of time will be carried round to form ring circuits. The conductors enter the high-tension junction-box through double glands in the sides of the box, each gland consisting of a number of rubber rings, not less than four in number, compressed around the conductor inside a substantial stuffing-box. Two covers are provided for the junction-box, the inner one having a watertight joint made through a rubber ring, the outer one being an ordinary street-box cover. The air contained in the junction-box when the joints are made is freed from moisture by a plate of chloride of calcium placed on the bottom of the box. Both the high-tension feeders and junction-boxes have been tested under current with 4,000 volts difference of potential, and have proved entirely satisfactory.

The engineers decided that in place of using a heavy con-

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ductor for the low-tension distribution wires they would use one section of conductor, and lay one, two, or three pairs of mains, according to the demand in the respective sections of each street, and the area of this low-tension conductor is ·0349 square inch section. As there are in those portions of the streets in which a considerable demand is experienced three pairs of these conductors, it became necessary, to distinguish each conductor along its whole run, to facilitate the joining up of the buildings on to the proper pair of conductors; and to ensure the recognition of each conductor, the coverings of the conductors are coloured—three red and three black, the black wires being in all cases positive, the red wires negative. Each of the three conductors, whether they be black or red, are further distinguished from each other by employing three different types of braiding, each of which has the advantage of not only appealing to the sight but also to the touch, and even in the dark a jointer can recognise any pair of cables he wishes. As in the case of the high-tension feeders these low-tension distribution wires are not carried directly into the transformer secondary terminals, but are carried into low-tension junction-boxes, which boxes are connected with the low-tension side of the transformer, and the design of these differs materially from that of the high-tension junction-boxes. Three sides of the low-tension junction-box are fitted each side with three pairs of glands, the fourth side being fitted with one pair of large glands. The heavy conductor from the transformer-chamber, usually 37/12 S.W.G., is carried through the pair of large glands to terminals within the junction-box. These terminals are connected to the distribution blocks through fusible cut-outs consisting of copper wires, contained in glass tubes to prevent injury to the fittings on the melting, and consequent arcing, of the fuse. All the low-tension distribution wires are sweated into sockets, which are secured by studs and nuts to the distribution blocks, of which there are three pairs facing the three sets of glands. The three distribution blocks are connected together with brass links, so that any one can be disconnected from the low-tension side of the transformer, and any pair of low-tension wires can be disconnected from the distribution blocks, isolating that particular pair only whilst a joint is being made, or for testing purposes.

The great flexibility aimed at in the design of these low-tension junction-boxes will be readily seen. It enables the low-tension wires throughout the whole system to be connected in the simplest manner possible in one continuous length, fed into at intervals by the transformers; or it enables each 300 yards of low-tension wire to be fed into by a single transformer, entirely disconnected on its secondary side from everything else but this particular section; or it enables several transformers with their respective sections to work in parallel, but entirely disconnected from the remainder of the low-tension system—in addition to the facilities for testing and joining up consumers' houses mentioned above. Again, the interposition of fusible cut-outs, not along the run of the low-tension mains, but between the low-tension main and each transformer, provides, with almost certainty, in case of accident to a transformer, for the fusing of its connection by the sum of the current sent through the low-tension mains from the transformers on each side of the faulty one, without the fuse of these latter transformers being melted, and the only inconvenience suffered by customers in the vicinity of this particular transformer would then be a drop in potential due to the greater length through which current would have to be conducted to their premises by the transformers on each side of the faulty one.

The transformers used are of three sizes—15, 25, and 30 kilowatts each. It will be noticed that where 30-kilowatt transformers are used the three pairs of conductors, each of ·0349 square inch section, have insufficient current-carrying capacity to distribute the output of a transformer of this size, and in all cases where this size transformer is used, the transformer and junction boxes are placed directly opposite the premises of a large consumer, who obtains the supply direct from the junction-box, without utilising the carrying capacity of the three pairs of low-tension conductors, which then only carry the balance of the output of the transformer to the smaller premises on each side. In joining the arc lamps in series to their conductors no special form of junction-box has been used. Care has been taken in arranging the position of the drawing-in boxes that one of these is placed opposite each arc lamp-post, and the arc light concentric conductor is divided in its outer conductor, and the two ends of the outer conductor joined to two separate 7/16 conductors, which are carried through a 2in. coated steam-barrel direct to the base of the lamp-post. The low-tension distribution wires are also tapped in this drawing-in box to supply current to the two 32-c.p. lamps contained on each lamp-post in addition to the arc lamp. This branch wire is a twin 3/20 S.W.G. wire, sheathed in lead to protect it from contact with the high-tension arc lighting wires, and carried to the base of the lamp-post through the same 2in. pipe as the former conductors. Several modifications of the ordinary methods of drawing-in and jointing the cables have been adopted by Messrs. Glover and Co. in carrying out this contract. The usual method of stripping the cable, turning back the conductor, and tying on a rope to haul it through the duct, is deleterious to the conductor, especially if any hard pull has to be used, and tends to mechanically weaken the insulation. In the drawing of these cables, however, the Voisey grip was used. This apparatus grips the conductor most effectively, and is easily attached to it. All joints on the conductors, some of which are of considerable size, have been well vulcanised, and the vulcanising of these joints has been carried out *in situ* by means of the portable vulcaniser made by Messrs. Glover and Co.

It will be appreciated by engineers that the extreme novelty of most of the plant used in this station might have been anticipated to have led to difficulties in the putting to work of the station, and credit is due to the contractors that the whole of the machinery has worked from the start with as great reliability as if it had been plant of less novel construction.

THE PACIFIC CABLE QUESTION.

Sir J. Pender has addressed the following further letter to Sir Charles Tupper in reply to the communication from the latter which was printed in our issue of 25th ult.:

Winchester House, Old Broad-street, E.C., May 30.

Dear Sir Charles Tupper,—Absence from home has alone prevented me from replying to your letter of the 17th instant earlier.

First.—Permit me to point out that although it be true that certain of the Australasian Governments have from time to time granted subsidies and guarantees to the Eastern Extension Telegraph Company, my statement that telegraphic communication with Australia was established solely by private enterprise is quite accurate, the subsidies and guarantees having been given for specific purposes other than the establishment of the communication. For instance, the subsidies were granted to enable the company to duplicate the Australian section of the line, not because it was unequal to the traffic requirements, but because the Governments and telegraphing public had found to their cost that no confidence could be placed in a single line; and as my experience fully bears out this view, I contend that if a Pacific cable is to afford the same measure of security as the existing system it must be duplicated. The guarantees were granted, as you are aware, to obtain the substantial reduction of tariff from 9s. 4d. to 4s. per word.

Secondly.—Your reference to the Berne list as your authority for stating that the Eastern Extension Company's original cables, although more than 20 years old, were still in working order, explains how you have been misled in the matter, the list only giving the dates when the early cables were first laid with their respective lengths, without showing the extensive cable renewals which have since been found necessary.

Thirdly.—As to the question of monopoly, I find on looking through the official report of the Colonial Conference (1887) that the remarks attributed to the late Mr. Raikes really referred to the following paragraph of a paper which Mr. Sandford Fleming read to the conference immediately before Mr. Raikes addressed the delegates—namely:

"Mr. Pender submits that the existing company (Eastern Extension Company) as the pioneer of telegraphic communication with Australia, is entitled to a large share of consideration at the hands of the colonies."

Consequently to represent this perfectly reasonable contention as a claim to a monopoly is simply absurd.

But none of these points have any important bearing on the real question at issue—namely, is the proposed Pacific cable an undertaking which can be recommended to the investing public?

The Pacific cable project, as I understand it, is as follows:

It is proposed to lay a single line of cable connecting Canada with Australia at a cost of £1.800,000, and in order to raise this sum guarantees for 14 years from the several Governments supposed to be interested to the amount of £72,000 per annum are to be obtained.

Now let us examine this proposal from the point of view of an intending investor:

Capital.			£1,800,000
Working expenses	£25,000		
Maintenance	35,000		
		£60,000*	
(*Note.—This is Mr. Sandford Fleming's own calculation.)			
Amortisation to replace capital at end of 14 years' guarantee	105,000		
			£165,000
Less earnings estimated on basis of one-half of the Eastern Extension Company's receipts from the Australasian traffic	45,000		
Four per cent. guarantee	72,000		
			£117,000
Leaving an actual loss to investors of (per annum) ..			£48,000

Suppose, for the sake of argument, we assume that the Pacific cable might one way or another obtain as much as the whole of the Eastern Extension Company's present Australasian receipts, even then there would be absolutely no return on the capital invested, and if the Pacific cable were duplicated the loss would probably amount to £120,000 per annum.

The above figures will, I am sure, be regarded by all conversant with the expenses attending the working and maintenance of cables laid in deep seas as not only moderate, but rather under the mark; for it must not be overlooked that no allowance is made for a prolonged interruption, a contingency which is very probable to a single cable laid in such extreme depths as have been proved to exist in the Pacific, and during which interruption the guarantees would, of course, cease to be paid.

I observe with some surprise that you quote with approval an-

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article which appeared in the *Globe*. It is evident that the writer knows very little of the subject, for he says in case of the cables between Aden and England being injured, all communication with India would be interrupted. As a matter of fact, no fewer than three other routes practically under the control of the existing system would still be open for traffic.

Again, I fail to understand on what grounds the writer holds that a single line of cable nearly 9,000 nautical miles in length laid in the Pacific should stand less chance of interruption than the existing cables.

With such figures as I have above placed before you, and which as a director of a submarine cable company you can fully appreciate, I would ask whether you would consider yourself justified in putting your name to a prospectus inviting subscriptions from the public for a scheme showing such disastrous financial results, even with the aid of the suggested Government guarantees.

I remain yours faithfully,

JOHN PENDER.

P.S.—I am sending a copy of this letter to the *Times*.

COUNTRY HOUSE ELECTRIC LIGHTING.*

BY SIDNEY A. COURT.

Large country houses, when in an isolated position, and out of reach of a gas company's supply main, are now usually lighted by means of electricity. By a country house the author means any large private house containing some 30 or more rooms, and requiring 100 or more points of light. Of such houses there are a great number in the United Kingdom, chiefly owned by comparatively well-off persons, who can afford to pay much more for the burning of a cleanly and steady source of light than they would for lighting by means of oil lamps. The lighting of small country houses is at present chiefly carried out by means of paraffin oil lamps, which necessitate a lamp-room, and the cleaning, filling, and trimming of the lamps regularly every day, and this is at once the cheapest and most convenient method of lighting where the total number of points required is below 100, but when above this number the work of cleaning and attending to the lamps becomes heavy, and in establishments where water has to be pumped for domestic use, or where the proximity of the "home farm" will conveniently allow it, the motive power for a dynamo during the evening is very conveniently combined with pumping water, cutting chaff, pulping roots, or sawing timber during the day. There are certain points to be considered in each individual case before deciding what method of producing power is best and most economical—such as cost of coal, coke, or paraffin oil delivered on the spot, if water power is available, and how far off, besides the position of the house itself, and also for how many months in the year it is usually occupied. Wind power for water-pumping purposes has of late come into use, chiefly owing to the great improvements in windmills, which are now of neat construction, and combine low first cost with slight expense for attention, while as a source of power the economy of its use is no less than 1½ times that of a steam pump, besides obviating the first cost of a boiler, and also doing away with the necessity for skilled attendance. The extra expense required is the storage, which should not be less than at least three days' average daily consumption, to allow for possible calm days, or when the wind velocity is less than six miles an hour. The author, by the kindness of Mr. Alwyn, of the Brush Company, has been able to lay before you a description of the plant and apparatus erected and used by Mr. H. C. Brush at his private house in Cleveland, U.S.A., where a 60ft. windmill is used for driving a dynamo, the current from which is stored in no less than 12 batteries of 34 cells each, each cell of 100 ampere-hours' capacity, giving a total of 40,800 ampere-hours stored. The author has made enquiries of several manufacturers of windmills, as also of electrical contractors, and can only discover one installation in England in which wind power has been used for electric light. In this solitary case the windmill was used to charge storage batteries, the mill being usually run during the day, driving a shunt-wound dynamo. This most interesting installation, which was at Messrs. Carwardine's Flour Mill in the City-road, in so far as wind power is concerned, is now disused, and gas has taken the place of the wind, and a gas-engine now charges the storage cells, and also works the mill.

Water power, if the supply is pretty constant, and not liable to dwindle to zero in summer, with a corresponding maximum of flood in winter, is the most convenient and economical source of power, though seldom available in this country; a notable example of its application is at the new installation at Chatsworth.

Steam power is more employed than any other, because cheap water power is comparatively rare; in nearly every available stream the milling rights are of considerable value, and the power is chiefly taken up by flour mills or other long-established businesses. Steam power plant is comparatively cheap to buy, and can be made portable at a slight increased cost. There is no necessity to discuss its application in detail, as it is so universal.

Gas power, by which is meant gas being generated, stored, and used on the premises, and not supplied by a public company, has made considerable strides in the last few years, chiefly owing to Mr. R. Dowson's inventions and improvements.

Oil-engines, in which the oil is admitted drop by drop into a "vapouriser," and then mixed with air and exploded, have lately come considerably to the front, being much simplified and improved in construction and economy of running. In a report by Mr. Worby Beaumont on some trials with a 6-h.p. actual engine in May, 1893, the cost with oil at 4d. per gallon came out as ·348d. per indicated horse-power at full load. As a fuel, oil at the present time seems likely to become extensively used.

In nearly all country houses where electric power is in use, motors of small powers can be conveniently used, and a move in this direction is slowly being made. Electric lifts can be used for hauling coal or visitors' luggage to the top of the house, or even for the speedy delivery of the dinner from the kitchen. Boot-brushing machines, knife cleaners, churns, are easily worked by a small ¼-h.p. motor, not to mention the convenience of larger sizes for raising water or pumping sewage. In the house, again, electricity is beginning to be used for cooking and heating, and in the latter respect, in particular, is of great use as affording a ready and convenient method of warming, and thereby airing rooms. Messrs. Crompton and Co. have lately made stoves a special line, and are now making cooking stoves of a size capable of preparing food for a household; they are built like gas stoves, but work with the natural advantage of absence of smell of gas and necessity for ventilation. For country house electric lighting purposes it is evident that some form of storage of power is necessary, because of the intermittent use of current.

THE DESIGN OF AN INSTALLATION.

An important point which should always be carefully studied when designing a country house installation, is the amount of current usually required, as well as what the maximum demand will be, for the local conditions should be carefully considered, as no two houses are alike in these particulars. In the case of a large installation, which becomes almost a so called central station, it may even be more economical to run direct during the time of heavy load, and use a small battery for the day load, and for after 12 p.m., while in a smaller installation it may be found better to lay down a smaller generative plant, and rely chiefly on the battery, charging up during the hours of the day, and thereby running at the maximum efficiency of the power plant. It is always best to have too large rather than too small a battery, for then in case of accident to the power plant we have spare storage to take its place, at all events, for the necessary lights. One of the most difficult problems that a consulting engineer is called upon to solve, and which requires most careful consideration, is the redesigning or arranging small installations originally carried out by contractors whose one aim seems to have been to lay down as much plant and apparatus as possible, without any consideration of local requirements. The author does not wish to suggest that this practice is universal, and no doubt much work, when originally carried out, was at the time considered to have been carefully planned; but of late special attention has been given to cost of running, and from experience gained by the pioneer installations, even a contractor, without a consulting engineer's knowledge to help him, should be able to design the proportions of generative plant and storage to the best advantage.

ANNUAL COST.

In comparing the annual expense of various small installations, stress is often laid on the cost per unit generated or supplied to the lamps, as if a house of some 200 lights could be compared with a central station with 20,000 lamps connected to its mains. To refer to a recent paper by Mr. Gisbert Kapp, it will be seen that the cost per unit generated, including repairs and 8 per cent. for interest and depreciation, for five private houses of from 70 to 720 lamps will average rather over 14d. (14·079). When, however, we analyse the results from installations of from 1,000 lamps and upwards where the current is in use daily, and for commercial purposes, we find that the cost falls at once to 3d. or even under. The author has obtained some figures of annual cost from three typical installations, when the power is in one case water, and in the other two steam, which are as follows:

CASE I.—WATER POWER.

Here the whole of the work required for damming the river and regulating the level of the water was already done, and the wheel existed, so the only expense incurred in installing the electric light consisted in arranging suitable gear and erecting counter-shafting for obtaining the necessary high speed for the dynamos. These are two in number, each of 120 amperes, 145 volts, and driven off the countershaft already mentioned. The current is conducted at a potential of from 110 to 140 volts, a distance of about a mile to the accumulators at the house, from whence it is distributed by an ordinary arrangement of regulating switches. Part of this main cable is of bare wire, supported on ordinary telegraph-pattern insulators fixed to wooden posts, and the last 300 yards is of insulated cable underground. The leakage on the bare portion of the cable in wet or snowy weather must be very high, and the greater part of the ground is liable to be flooded after every heavy rain. The storage battery consists of a set of 57 K-type E.P.S. cells, lately installed, and replacing 55 of L type. As the lights in the house and stables number about 200, on occasions when much light is needed one dynamo has to be run to supplement the storage.

This installation is particularly interesting as being now nine years old, and one of the comparatively few in England where water power is available; the original cost of the plant and apparatus, including wires and fittings, was over £3,000. It is not difficult to arrive at the total annual cost of production. Repairs and renewals to the dynamos, cables, fittings, not including interest and depreciation, have amounted on the average to 10·8 per cent. per annum on the prime cost; and the battery renewals, including the latest complete renewal of the entire

* Abstract of paper read before the Civil and Mechanical Engineers' Society.

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battery, work out to 14·6 per cent. The labour bill cannot be put at more than 10s. per week, or £26 per annum, as the man in charged is not a skilled electrician, and has also to attend to the various agricultural machinery driven off the same waterwheel which works the dynamos. The units supplied to the lamps can only be guessed, but it is fair to take them as equal to those required by houses of equal size in London supplied by a public company, which amount to about 12 B.T.U. per lamp per annum, or for the 204 lights, 2,448 total units. Including interest and depreciation at 8 per cent. on the cost of the generating plant, cables, and wires, and adding the average cost of repairs, putting labour at only £26 and petty stores at £10, brings the total annual cost to €569, or 55·7d. per unit, or £2. 16s. per lamp per annum. And if looked at as purely "out-of-pocket" expense. the annual cost has actually averaged £369. The whole plant and apparatus is considered to be now in good order and condition.

CASE II.—STEAM POWER.

The power plant consists of a compound-wound dynamo, driven by a vertical single-cylinder steam-engine, the boiler being vertical and tubular, and the storage one set of 53 K-type cells. The number of lamps fixed is 340, of which 100 are usually burning every day; in addition to the lighting, the current is used to supply a motor about 400 yards away, which actuates a pump, and raises water to a high-level reservoir. The current required for this amounts to 2,000 units per annum. The annual costs are only available for two years, and work out as follows:

1892.	Total cost, including renewals, interest, and depreciation as before (8 per cent.)..	£478
	Which, assuming again 12 units per lamp fixed, gives 4,080, and plus the pumping, a total of 6,080, at a cost of..	17·9d.
	The out-of-pocket expenses were.....	£258
1893.	Total cost, calculated as before.....	£406
	The coal bill was fully 25 per cent. lower, owing to the units consumed being less in number; taking them at 10 instead of 12 gives the total units as 5,400, and the cost at (each)	18d.
	The out-of-pocket expenses were	£196

Note.—No spare plant. When all lights are on it is a strain on engine and boiler; they must be run at full load of 80 amperes, and assisted by the cells to give the 150 required, nor is even a spare armature available in case of a breakdown. The plant having only been in operation for two years is in good condition. The cells have lost a good deal of paste, and in future years the repairs to the cells will no doubt be costly, and the annual expense will then work out higher.

CASE III.—STEAM POWER.

Here we again have steam power, but of ample size to supply more than the total requirements of the house, without calling upon the battery, also of ample size. The generative plant consist of a compound engine and shunt-wound dynamo, the latter giving 120 amperes and 140 volts, while the battery consists, or rather consisted, of two sets of 32 L-plate cells, capable of 120 amperes discharge. The number of lights fixed is equal to 205 of 8 c.p., which at ·4 ampere each requires 82·0 amperes only. The drawback to the arrangement of power and storage units is that, except when charging both sets of batteries in parallel, the engine and dynamo can never be worked at more than half load; it would have been far better to have arranged the generative power capable of supplying 80 amperes as a maximum with 100 volts, which would have been ample for running direct, if required, or for charging one-half of the battery, would have been always running at practically full load with 60 amperes and 140 volts. The battery being so large could have been economically charged in alternate halves, while, if as arranged, both halves are charged in parallel, the generative plant will stand idle for fully four days a week in summer, or two at least in winter. It is true that the engineer's time is not required all or every day, and therefore is available for other work on the estate. The annual costs for three years are as follows:

1891.	Total cost, including interest and depreciation, etc., as before.....	£445
	Cost per unit, 12 units per lamp for 225 lamps fixed.....	39·4d.
	Out-of-pocket expenses were.....	£148
1892.	Total cost	£452
	Cost per unit	40·2d.
	Out-of-pocket expenses	£155
1893.	Total cost	£483
	Cost per unit.....	43d.
	Out-of-pocket expenses	£186

The reason of the great difference between the out-of-pocket expenses and the total cost is accounted for by the fact that at the present time one-half of the battery is on the rubbish heap, and the other half should by rights be there also, and so the author has divided the cost of the cells into three portions, and put down one to each year as, strictly speaking, due to debit. But to repeat such figures and facts are tedious and do no good; they are only given in this paper to emphasise what the author has already referred to above as showing how very expensive a lazy or incompetent man in charge will be, and also how the effect of bad arrangement to begin with bears its fruit in due season. In the first case brought before you this evening, the battery renewals have come out high, as there is no one on the premises who in the least understands treatment of storage cells, and in the last case a valuable battery by consistent neglect has been irretrievably ruined. In the second case, only two years' account being available, the cost per annum is very reasonable, and not above what a private house installation usually costs. It evidently is by far the best policy to arrange for the battery to be regularly inspected, not by the contractors who supply, but by the manufacturers, even if the cost of maintenance is as high as 10 per cent. per annum.

TRAMWAY TRACTION IN NEWCASTLE-UPON-TYNE.

REPORT BY THE BOROUGH ENGINEER.

We give below the report prepared by Mr. W. Geo. Laws, M.I.C.E. (city engineer of Newcastle-upon-Tyne), for the Town Council concerning three systems of tramway traction.

By a minute of May 21, 1894, you asked me to give you a report on the three systems of tramway working which you considered might be applicable in Newcastle—viz.: (*a*) the horse traction system; (*b*) the conduit electric system; (*c*) the cable system.

You advisedly excluded the overhead electric system, while the accumulator method has hitherto given such lamentable results that you thought it not worth consideration. You decided, in fact, that the three systems mentioned above only were in the running, an opinion which I fully endorse. I now submit the report, having condensed it as far as possible in the hope that, though much more might have been said on the subject, yet that all the chief points that should guide you in your decision have been touched upon.

(*a*) THE HORSE-TRACTION SYSTEM.

This is the system at present in use at Newcastle, and in many respects it fails to meet the public wants. The main facts of the Newcastle tramways are as follows:

The mileage open (single line) is	14 miles.
The length of route worked	9 miles.
The number of miles run, per annum	615,000
Passengers carried, per annum	3,890,000
Receipts per mile run	12·65d.
Expenses per mile run	11·25d.
Average total receipts are	£32,000
Average total expenses.....	£29,000

Number of cars, 34. Number of horses, 281.

The service of the chief lines of route is at 10-minute intervals to and from Scotswood, Gosforth, and Byker; 20-minute intervals to and from Elswick and Arthur's Hill; and at 40-minute intervals to and from Jesmond-road. The average speed of the cars (exclusive of waits at terminus) is five miles per hour. There is no attempt made to cultivate the short or immediate traffic, and no one who is in a hurry dreams of waiting for the cars. At present, anyone who has to go a mile can be pretty sure of walking it before a car passes him, and even up to 1½ miles he has an even chance of coming in first, and will certainly "save his distance." Thus, only the long-distance traffic is catered for, and the short 1d. fares are as far as possible discouraged. If the cars were run at intervals of five minutes or less, everyone could reckon on not having to wait longer on the average than 2½ minutes, and many more persons would use the cars for short distances. The invariable result in towns has been that quickening the service—that is, reducing the intervals between cars—has greatly increased the total number carried, and reduced slightly the average distance travelled. And those lines which have catered best for the short-distance riders have been most successful in reducing the expenses per car mile, which is the great secret of success in street tramways. Horse traction, therefore, must soon become a thing of the past, except in country districts and for feeder lines.

Every car requires four pair of horses to keep it running, and they must be fed; and in practice it is found that it is not possible to reduce the cost on the horse system below 10d. per car mile, which cost is not at all affected by the numbers carried, and varies only with the price of hay and corn.

(*b*) THE CONDUIT ELECTRIC SYSTEM.

This system has not as yet had an extensive trial in England, and, unfortunately, the limited experience obtained has not been very happy. Thus, at Blackpool, where a conduit system was laid, and promised well for a while, when taken over by the Corporation it gave so much trouble, owing to excessive leakage and deterioration of the apparatus, that for some time it has been worked by horses. One or two other small conduit systems in England have proved failures. There has, however, been an installation of the conduit system at Budapest, in Hungary, which has proved successful, both mechanically and commercially, and where the cost per car mile has been brought down so low as fairly to bring the system into the field as a strong competitor. It will be fair, therefore, to take the figures of this system, making such modifications as are rendered necessary by the different conditions of the case to reduce it to English standards. Thus, Pesth is specially favourable for electric traction, being practically flat. The chief streets are extremely wide, sometimes 150ft. and 200ft., and this allows of the tram lines being run outside of and parallel with the ordinary traffic, while leaving ample room for carriages and carts alongside the footwalks. In consequence of this peculiarity the speed of running is much greater than could safely be allowed in our narrow and crowded

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streets. Labour in Pesth is one-third less than in England, while fuel is one-fifth more. The chief facts in Budapest are:

Mileage open (single line)		14 miles.
Length of route		7½ miles.
Miles run, per annum		1,437,000
Passengers carried		11,000,000
Receipts per car mile		11·86d.
Expenses per car mile		6·32d.
The cost per single mile of		
Construction	£12,000	
Equipment	2,750	
		£14,750

The service on the electric route is at intervals of 1½ minutes, and the average speed is 12 miles per hour—viz., 9·3 miles in the heart of the city, 11·16 in the residential parts, 15·5 in the suburbs. The cars are small, to seat 20 passengers only, but with wide platforms, on which many stand. They have no seats on top. The population of Budapest is 520,000, but as the tramways are laid in Pesth, probably 300,000 is a fair estimate of the population served. Buda, on the other side of the Danube is hilly, while Pesth is perfectly flat. The difficulty of working electric lines on any but very flat gradients has prevented the extension of the system into Buda, and the authorities are now enquiring into the possibility of introducing the cable system there. Commercially, the result in Pesth is that the shareholders have received dividends of 7 per cent. in 1892, and 8 per cent. in 1893, while a tax of 2 per cent. is paid to the authorities for the concession. On a total capital of £284,000 (which includes, however, some miles of steam lines), the earnings were, in 1892, £68,893, of which, after payment of expenses, about £24,100 was available as profit, and £17,500 was divided among the shareholders. For 1893 the figures were:

Capital expended	£284,000
Total earnings	81,330
Net earnings	32,452
Divided as profits	26,666

These figures have been taken from the officially published balance-sheets of the company.

There are some specialities of construction which must be noted as bearing on the applicability of such a system to English towns, and especially to Newcastle. For these particulars the committee is indebted to Mr. W. N. Colam, who visited Budapest in the course of business, with a view to see the details of a system that promised so well, and who has put the results of his investigations before you. The construction may be broadly described as the same as the cable system—viz., with a conduit underground to carry the moving power, but with this difference, that while in the cable system the conduit for the rope lies in the centre of the way between the rails, in the electric system it is placed under one rail. At first sight it would appear as if this was a distinct saving in first cost by avoiding the central slot rail; but the saving is more apparent than real, as the actual cost of the way is about £1,000 per mile more than in the central-slot system. Besides this, however, there are disadvantages as compared with the central slot which are very serious and more than counter-balance the saving of the central rail. The central slot is not subject to wear and tear from the flanges of the wheels since they do not run in it, and consequently there is no tendency to wear it down or widen it, and it remains permanently at its original width of ⅝in., and the edges remain unworn. With the conduit under one rail, on the other hand, the slot takes the flanges of the wheel and it is subject to rather heavy wear and the edges are rapidly rounded off and the slot widened. The width required to allow the electric "collector" to pass is larger than is needed for the cable "gripper," for while all the power of the gripper may be conveyed by a plate ½in. thick, the electric "collector," though thinner, has to be protected on each side by "insulators," and these again have to be defended from wear by iron plates on either side. The result of this is that the original width of the electric slot must be at least 1¼in. or 1⅓in., rather more than double that of the cable slot. As a matter of fact, Mr. Colam found that in Pesth the slot was in no case less than 1¼in. in width, while this had in many cases, and especially at curves, been enlarged by the wear of the wheel flanges to 2in. This very wide slot, which is tolerable in Pesth, where the ordinary traffic need not cross the tram lines except at a safe angle, would be a nuisance in our streets, where the horses wear caulkers, and where the ordinary cart and lorry traffic must work over the lines at all angles, while a bicycle wheel would drop through altogether with the risk of "short-circuiting" the conductors, and stopping the traffic on the line within that section. The electric system needs a quick means of getting at the underground conductors to remedy defects of insulation and for cleansing of the conduit, which is specially necessary to prevent accumulations of dirt or water, which at once stop the work by "short-circuiting." To provide this means of easily getting at the tube, two courses of brick in mortar are laid under the rails on the top of the concrete conduit, and when any stoppage occurs a rail is taken up, these bricks pulled out, and the necessary repairs done, after which the bricks and rails are replaced. This seems rather a clumsy way of working, and if it has often to be resorted to would become an intolerable nuisance in our crowded streets. It may answer in a town where the streets are so wide (as in Pesth) that the ordinary traffic has room to avoid the chasm laid open without being seriously inconvenienced, but with us, where every foot of the street width is used, and the ordinary traffic uses, and must use, the tram lines quite freely, such a system would be unworkable. There seems reason to fear also that the electric conduit, which seems to be specially susceptible to dirt even in a dry climate, would be more so in our wet and muggy weather, when the amount of mud that must pass through so wide a slot would cause constant trouble, and interruptions from that cause would be even more frequent. This seems to have actually been the case at Blackpool, and to have practically made the conduit system unworkable as first laid down, so much so that it is at present given up for horse traction, pending extensive alterations by which the Corporation hope to overcome the difficulties. Snow, too, has been found very difficult to deal with on the electric conduit, and has occasionally stopped the lines for days together. The use of loose brickwork for the rails to rest upon makes the Pesth road rather a flimsy one, and such as would not satisfy us here. It seems to be only tolerable where the street width allows the ordinary street traffic to avoid the tram lines.

There seems to be good reason to suppose that the very successful financial result in Pesth is due to local conditions and could not be realised in England—or at least in English towns. The chief reasons that would increase the expense of working per car mile in England are:

1. The cheaper labour obtainable abroad—viz., 33 per cent. cheaper for half-skilled labour, such as conductors, drivers, clerks, etc., and nearly 50 per cent. cheaper for cleaners, greasers, and the like.

2. The very high speeds allowed in the streets—viz., an average of 12 miles per hour, as against eight miles, the utmost hitherto allowed in English towns. This at once increases the car mileage and shows reduced cost.

3. The difficulty of applying any electric systems to towns where there are hills to surmount. The increase of power required to take an electric car up a moderate hill is out of all proportion to the work done. Thus, a car which would consume 10 e.h.p. on the level would require 28 e.h.p. to carry it up 1 in 20, and 36 e.h.p. on 1 in 10, the speed on 1 in 20 being also reduced 40 per cent., and on 1 in 10 by 66 per cent.; or, to put it in another way, to carry the same load at the same speed up 1 in 20 would require four times the power, and up 1 in 10, 11 times the power required on the level. This involves the further disadvantage that each car must carry motors powerful enough to surmount the steepest hill on the route, although they are useless dead-weight on the level. For instance, a car must carry motors in Clayton-street four times more powerful than necessary, in order that it might be able to crawl up Westgate-hill at one-third the speed. This is not very promising for electrical traction in such a town as Newcastle or Leeds, and yet engineers on both sides seem to be agreed as to the fact of the unsuitability of electric motors for even moderate gradients. They differ only in their estimate of the waste of power, but, taking the most sanguine figures, it is practically fatal to cheap transit.

4. The moister English climate is unfavourable to the rather delicate apparatus, and promotes leakage of energy by keeping the conductors damp, and would also presumably require even closer attention to keeping the tube clean. A piece of damp paper (such as we see too much of in the streets) would, if blown or dropped through the slot, and falling on the conductors, be enough to short-circuit them and stop all traffic on that particular section until its whereabouts was discovered and it was removed.

It is difficult to estimate the actual increase in cost per car mile for each of these items, except in the case of No. 1. Allowing for dearer labour and cheaper coal in England raises the car mile cost by ·75d.—viz., from 6·32d. to 7·07d. The difference produced by No. 2—that, is the lower working speed here—can only be inferred by working out the reduction in car-mile cost made by increasing the speed on the cable roads; but taken in this proportion would be about ·80d. The difference caused under No. 3—viz., the disadvantage on gradients—would depend greatly on the proportion of steep streets worked on the system. Assuming that in Newcastle the proportion of steep gradients is one-third of the whole, the total power required would be increased as 5 to 3, which would mean an addition of about ¾d. per car mile. Under No. 4—the influence of climate on the system—there is no means of making an estimate. It might be so great as to stop working altogether, as at Blackpool. Putting all these together, the probable cost is raised to 8·62d. per car mile, which corresponds pretty closely with American experience, where the best information that can be got puts the cost per car mile of electric traction at the best at 1½d. below horse traction, which brings it to 10½d. in America, where prices of labour are high. Assuming horse traction here, in Newcastle, to cost 10d. per car mile, which is about the figure, that would bring the electric system to 8·50d. as compared with 8·62d. as obtained above. There is one point which should not be forgotten in comparing the results at Pesth with those, say, in Edinburgh—viz., that the average fare per passenger is 1·4d. in Pesth, against 1·1d. in Edinburgh. To bring the fares there down to English standard would at once reduce their traffic receipts by £12,000, and take just 5 per cent. off the dividends earned. The fare system abroad is somewhat different to that prevailing in England. We stop to pick up at any point where a passenger may call; on the Continent the "stations" are fixed, and cars do not stop between. In Pesth they have also a plan of using fare-books, by which considerable saving is effected. Thus, though their lowest single fare is 2d., return and season tickets bring down the average fare to rather under 1½d.

(c) Cable Traction System.

In this case one has surer ground to work on, because the system has been extensively tried both in America, England, and elsewhere, so that the costs both of construction and working are pretty well known. It is not necessary to describe the system in detail, further than to remind you that the power in this case is

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applied by means of an endless rope travelling at a fixed speed in a conduit very similar in shape and size to that required by the conduit electric system, but placed in the centre between the two running rails, and forming practically a third rail, with a narrow slot through which the "gripper" takes hold of the cable below. These cables, which run up one line and down the other, are drawn at a fixed speed from central stations placed in the most convenient spots obtainable. This speed in England is limited to eight miles per hour, as at Brixton, but in Edinburgh was further limited by the local authority to six miles. It is found by experience that the limit of length of cable which can be economically worked from one engine house is about six miles—that is, three miles out and three home again—so that an engine station placed centrally in a town can work any route which lies within a radius of about three miles from that centre; and, of course, any number of cables can be worked from the central engine-house by providing a like number of driving drums and engines of sufficient power. As the car when travelling is attached by the gripper to the cable, it travels at the same speed, less any slip in the gripper; and in going down hill it also travels with the cable, and so long as the gripper remains tight cannot run away. This is one of the peculiar advantages of this system, that so long as the machinery is in good order, the car is under complete control. The power absorbed in moving the rope is, of course, constant, and every additional car put on only consumes the power required to move its own load, and this applies equally to level ground and to gradients, since the descending cars always balance within a small fraction those ascending; in fact, the only loss in that respect is the small amount due to the "friction" of the car wheels and axles, and to the "stiction" of the wheels on the rails. As no part of the power required to drive the car passes through the wheels and axles, these can be made as light as for horse cars, and the wear and tear on the rails is reduced to a minimum; whereas, in all systems electric, steam, or otherwise where the car is driven by a motor, not only is there a greater friction, causing greater wear of rails, but the wheels and axles must be heavier, and, in fact, the whole car must be made heavier to give sufficient adhesion for driving. As the cable travels at a fixed speed, the journey time of the car must always be less than that speed would allow, and, in fact, with a cable travelling at eight miles per hour the car will only average seven miles, or less. The special feature of the cable system, that every additional car put on only adds a few pounds of coal consumed at the engine-house, but does not increase the fixed charges, while it does not increase the car mileage, renders it specially applicable to a growing traffic and to the further development of traffic. The experience of Edinburgh has been that as soon as the receipts reached 1s. per car mile, it was policy to put on more cars, reducing the earnings, but also reducing the expenses in a greater ratio. Thus, when the line first started, the earnings were 1s. 5d. per car mile, and the expenses the same, leaving no profit. Now, by constantly adding cars the receipts have come down to 11d., and the expenses to under 7d., leaving 4d. per car mile of profit. When, as at Brixton, the traffic to be won is large, the results have been still more startling, the service having been quickened by adding cars till they now run at one-minute intervals, while the expenses have been reduced to something under 4d. per car mile. At Brixton, also, a further alteration has been made by reducing the fares to ½d. per half-mile, instead of 1d. per mile—that is, by catering for the short distance traffic. The experience of Birmingham, where four systems are at work under the same company, shows that cable is earning 6d. per car mile, steam nearly 4d., horses 1½d., electric (accumulator) losing 2d. The disadvantages of cable traction are:

1. The high cost of construction, which is about £10,000 per single mile—less, it is true, than electric conduit, but double that of horse lines. The cost of equipment, however, is only £1,000 per mile, as against £2,750 on the electric system. A cable car, complete, costs about £220, while an electric car costs about £700.

2. The central rail is a further interference with the streets, and with the ordinary street traffic. It is true that that has been minimised in the most modern construction; still, it is an interference, and nothing but the conviction that the advantages which the cable system offers to the public in the way of quick and cheap transit are so great, would have overcome my objection to it on that ground.

Some other objections have been raised, as, for instance, to the noise made by the rope running over the sheaves. These seem chiefly sentimental. It is difficult to understand how such a noise, if it exists, could be heard over the ordinary noise of the traffic in paved streets. In Edinburgh, where the ordinary street noise is less than usual, the cable is not audible except by stooping over the slot. At Brixton, where the ordinary traffic is much larger, the cable will be even less heard. The question has been asked of me why the construction of the cable road could not be cheapened by laying the tube or conduit under the one rail, as in the Budapest system, and so avoiding the objectionable third slot rail. The mechanical objection is at once apparent that the pull on the car would be all on one side, and would tend to twist it, wearing the wheel flanges and rails unduly, and giving the car a tendency to always take points and turn-outs on the side opposite to the pull. It has lately come to my knowledge that this system has been tried on the Lisbon tramways, where it failed for the very reasons given above, and gave so much trouble that it was in contemplation to reconstruct the line to get over the difficulty. Up to this time that has not yet been done, but the system has been definitely condemned. The Pesth experience affords a further reason for avoiding any system where the flange of the wheel travels in the slot, as the great wear which has taken place renders the slot wider and more dangerous every day. The figures of the cable system, applied to Newcastle, would come out as follows:

Cost of construction	£10,000 per mile.
Mileage worked (single) would be	24 miles.
Length of route	12 miles.
Number of miles run, per annum	1,500,000
Number of passengers carried, probably	10,000,000
Interval between cars	5 minutes.
Probable earnings, per car mile	8·25d.
Probable expenses, per car mile	4·5d.
Number of cars running	50
Average fare per passenger	1¼d.
Average length of journey	1¼ miles.

These figures are based on the working of the Edinburgh lines, and the probable number of passengers is estimated from the average of six large towns, including Newcastle. This average shows 38 times the population carried every year, but the figures given above are based on 50 times only.

Having now laid the chief points of the three possible systems of tramway traction before you, it may be expected that I should express some opinion as to which seems to promise the best results for the town and the public. It seems unnecessary to further consider horse traction at all. It has done fairly well in the past, and has served its purpose, and become obsolete as not meeting the public wants. The town, in fact, has outgrown it, and wants something more modern and offering greater facilities both in speed, accommodation, and cheapness; and, indeed, the object for which your committee was appointed was to find some better system of mechanical traction. This reduces the matter, then, to a choice between the electric conduit and cable traction systems, and whichever of these affords the greatest advantages in cheapness of construction, cheapness of working, convenience of service, and cheapness of fares should be that you will choose. There are two or three general considerations that seem worth formulating before going further, as they bear directly on the question—viz.:

(*a*) Whatever system is chosen, the capital cost of constructing the lines must be undertaken by the Corporation. This is the only method by which they will retain the control of their own streets, and by which they are not left at the mercy of their lessees at the end of the lease. They might otherwise find themselves compelled either to re-let the lines to tenants for whom they did not care, and on terms they did not think favourable, or to purchase the undertaking at a cost far beyond its real value, because they, the Corporation, would have to provide for the carrying on of the service immediately it was given up by the lessees. The method provided in the Tramway Act for acquiring the undertaking by arbitration is expensive and uncertain, and where it has been exercised, corporations have generally discovered that they have had to pay more heavily than if they had laid out their own money to begin with.

(*b*) The system adopted must be one that is commercially successful, so that there is no need to subsidise it from the rates.

(*c*) It should be so successful as not only to pay proper interest on the capital expended, and to redeem that capital during the period of the lease, but also to afford a fair margin of profit on the capital laid out by the lessees themselves. It is clear that the only real security for the payment of interest and redemption on capital, is that it shall be the interest of the lessees to hold the lines as long as possible, and that can only be where they get a good return for their money.

(*d*) The above results should be realised with so low a scale of fares as to make the tramways a real boon to the public using them.

(*e*) The mode of construction adopted should interfere as little as possible with the use of the streets for ordinary traffic.

Bearing these points in mind, it seems to me that as to cost of construction there is not much to choose between the two systems. The electric, apparently, has cost more in Pesth, in spite of cheap labour; but there seems no real reason why it should. The work to be done is practically the same—viz, to lay a conduit for the conductors or cable and the rails. There should be little or no difference in first cost. The cost of equipment is certainly much larger for electric haulage, and must necessarily be so, since motor cars cost about three times as much as cable cars, but this is a matter more for the lessees than the Corporation, as equipment is a lessee's cost. It is only important as affecting the amount of money that must be earned to pay interest on capital. Cost of working is the next consideration, and here the advantage is in favour of cable haulage. Budapest shows a very good result; but, as has been shown, this result has not been realised in America, and is not likely to be realised here, while, on the other hand, both English, American, and European experience has confirmed the low cost per car mile of cable traction, and the fact that the larger the mileage run the less the average cost. The cost of cable haulage in America on the larger lines is put at under 5d. per car mile, which, allowing for American prices, would correspond to about 4d. here. Where it has had a favourable chance, as at Brixton, that result has already been realised, and on popular fares, too. Applying Edinburgh results to Budapest figures shows that with such a service—viz., 1¼ minutes, and carrying the same number of passengers—the cable would be worked even below 4d., thus beating electricity on its own ground. Here there is less difference in convenience of service, for the Budapest service is excellent—viz., 1¼ minutes between cars, and high speed—which, however, could not be allowed in English towns; but beyond this there is the great difference that while electricity is heavily handicapped by even moderate gradients, and must either go at a slow speed or wastefully use energy—in

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fact, must either "crawl" or "cost." Cable, on the other hand, takes no account of hills as steep as Westgate, but goes at the same even speed whether on the level or up or down gradients as steep as 1 in 11. This is a very great point, and, to my mind, points unmistakeably to the cable as the only system really suited to Newcastle. Cheapness of fares has already been touched upon, and here again the cable has the advantage, not only in running at cheapest fares already, but as affording the prospect of still further reduction as traffic increases. In the latter quality it stands alone as the one system where it is to the interest of the lessee to reduce fares. All the others have a minimum below which the cost cannot be reduced, no matter how many cars are run or how many persons travel.

Finally, there is a fair prospect of the Corporation being recouped for their outlay and getting interest and redemption duly paid to them. The figures on page 13 are the best warrant for this. They have been studiously kept moderate and are based on the average of results obtained in other similar towns, to which the lowest scale of fares has been applied. They show that to pay interest and redemption on capital will require 2½d. per car mile, and that 4½d. will pay working expenses, so that if the tramways earn 7d. per car mile the Corporation is secure.

It seems to me that the cable system is on all counts the most suitable for Newcastle, and, further, that it is a safe investment for the Corporation, and beyond that a reasonably promising speculation for the promoters.

BUSINESS NOTES.

Derby.—The Town Council have decided to light the baths by electricity.

Norwich.—The electric light is to be installed in the Norfolk and Norwich Library.

Great Northern Telegraph Company.—For the month of May the receipts were £22,800.

Worcester.—The question of the electric lighting of the Victoria Institute is under consideration.

Western and Brazilian Telegraph Company.—The receipts for the week ended June 1 were £2,637.

Brechin.—The Police Commission intend to apply for a provisional electric lighting order for Brechin.

Removal.—Messrs. Lowdon Bros. have removed to the Temple Electric Works, 37, North Tay-street, Dundee.

Liverpool Overhead Railway.—The traffic receipts of this railway for the week ended 3rd inst. amounted to £830.

Tenders for Coventry.—The Town Council invite tenders by the 13th inst. for the erection of an electric light station.

Blackpool.—The Methodist Free Church in Adelaide-street has been enlarged, and the electric light has been introduced.

Tenders for Stores.—The Caledonian Railway Company invite by the 18th inst. tenders for the supply of telegraph and electrical appliances.

Dewsbury.—Considerable progress has been made with the construction of the engine-house, etc., for the Corporation electric light station.

Eastern Telegraph Company.—The receipts for the month of May were £54,846, as against £57,946 for the corresponding period of 1893.

City of London.—The Library Committee of the Corporation recommend the lighting of a portion of the Records Chamber with the electric light.

Burton.—Messrs. Hewes and Geary, of Church Gresley and Coalville have secured the contract for the electric lighting of the Cadley Hill Colliery.

West India and Panama Telegraph Company.—The receipts for the two weeks ended May 31 were £1,233 less than for the corresponding period of 1893.

Eastern Extension Telegraph Company.—For the month of May the receipts show a decrease of £1,435 as compared with the corresponding period of 1893.

Appointment Open.—As will be seen from our advertisement columns, a competent assistant electrician to chief engineer of central lighting station in British Guiana is required.

Edinburgh.—The Town Council have authorised the resident electrical engineer to go to London from time to time during this month to be present at tests of the electric lighting plant.

Preston Gas and Electric Lighting Bill.—This Bill, to which we referred in our last issue, was approved, with certain conditions, on Tuesday by a Select Committee of the House of Commons.

Batley Carr.—Messrs. Alfred Hill and Sons, of Batley, have instructed Mr. A. Richmond Turner, of Dewsbury, to put in an installation to light the whole of their premises with the electric light.

Dudley.—The Street and Gas Committee have recommended the Town Council to grant Mr. F. W. Cook, of High-street, permission to lay wires for electric lighting under a portion of King-street.

Reading.—An arcade and shops are being erected by Mr. C. Fidler which will be lighted by electricity. The installation has been entrusted to Messrs. T. C. Williams and Son, London-street, Reading.

Weston-super-Mare.—An engineer is to be chosen by the Electric Lighting Committee, at a fee of 50 guineas, to report on the questions of electric lighting, electric tramways, and refuse destructors.

Cowper Coles Galvanising Syndicate, Limited.—This Company has been registered, with a capital of £2,000 in £1 shares, to carry on business as electrical engineers, manufacturing chemists, etc.

Burnley.—It is announced that the firm of Messrs. Driver and Co., organ builders, of Hammerton-street, are the first to apply electrical energy locally as a motive power for the driving of wood-working machinery.

E. Wallace and Co., Limited.—This Company has been registered, with a capital of £1,000 in £1 shares, to act as agents for manufacturers of all kinds of goods; in particular of chemical, mechanical, or electrical goods and appliances.

Change of Address.—The St. Martin's Electrical Manufacturing Company, Limited, during the extension of their business premises, have taken offices at 6, Adam-street, Adelphi, Strand, where all communications should be addressed.

Glasgow.—The Clyde Navigation Trust have decided to make the buildings for the hydraulic installation at Cessnock Dock large enough to afford space for electric lighting plant, should the Trustees decide to light the dock with electricity.

Battersea.—The Battersea Vestry have referred to the Electric Lighting Committee a motion by Mr. C. Marson, that "considering the great expense of the horses of this Vestry, the Vestry is of opinion that electric motors be used in place of horses."

Telegraph Manufacturing Company, Limited.—The annual ordinary meeting of the shareholders of this Company was held on the 4th inst., and the same dividend as last year was declared—viz., 5 per cent., and in addition a bonus of 2½ per cent.

Hotel-Lighting.—Messrs. Rashleigh Phipps and Co., of 102, Oxford-street, have received the contract for the lighting of the Norfolk Hotel, Surrey-street, Strand, for 425 lights of 16 c.p. The work has to be finished in the short space of four weeks.

St. Austell.—In the House of Commons on Wednesday, the Bill confirming the provisional order of the Board of Trade conferring electric lighting powers on Veale and Co, Limited, in regard to St. Austell, was ordered to be read a third time.

Yeadon.—The Board of Trade Provisional Order Bill, authorising the Yeadon Local Board to make electricity and to supply the current to consumers by meter, has passed the Examiner in the House of Lords, and has been ordered to be reported for second reading.

Balruddery.—The starting of the new organ at Balruddery by Dr. Peace, of Glasgow, will take place on Saturday. Mr. Hope Jones will be present. This organ is a reconstruction on the Hope Jones electric system of an organ of about 25 stops, besides couplers.

West Hartlepool.—The Electric Lighting Provisional Order (No. 1) Bill has been read in the House of Commons a third time and passed, subject to the Royal assent. Its object is to confirm a provisional order made by the Board of Trade under the Electric Lighting Acts.

Sunderland.—The Corporation have received a report from Prof. Kennedy on the proposal to light the town electrically. He estimates the cost of arc lighting at £1,500 a year, or £550 more than gas lighting, but the amount of illumination would be 20 times greater.

Cardiff.—The Property and Market Committee of the Town Council have decided, since the electric light will soon be installed, to have the light in the market and Town Hall. The committee have decided to ask the borough engineer to formulate a report upon the matter.

Elieson Electrical Switch, Limited.—This Company has been registered, with a capital of £5,000 in £1 shares, to acquire, develop, and turn to account the patent rights for Great Britain and Ireland and the English colonies relating to improvements in electric switches or circuit-breakers.

Rawtenstall.—The town clerk's office, the borough surveyor's office, the central fire station, Lord-street, Rawtenstall, and the police station, have been connected with the National telephone system, so that communication now exists between those offices and all parts of the country.

Aberdare.—The Board of Trade Provisional Order Bill, empowering Messrs. J. C. Howell, Limited, to make and supply electricity through mains in Aberdare, has passed the Examiner on Standing Orders in the House of Lords, and has been ordered to be reported for second reading.

Telpher Cable and Cliff Railway Syndicate, Limited.—This Company has been registered with a capital of £6,000 in £10 shares, to acquire the concession granted to Mr. W. J. Brewer, C.E., authorising the construction of a cable across the Dyke at Brighton and a cliff railway to the Punch Bowl.

St. Pancras.—The Vestry have decided to reduce the price of current for public street lighting from 6d. to 5d. per unit after Michaelmas quarter next. The tender of Messrs. Kelly Bros., of Liverpool, for the erection of the new electric station buildings in King's-road, at £6,729. 13s. 6d., has been accepted.

City and South London Railway.—The receipts of the Company for the week ended June 3 were £869, against £914 for the same period last year, or a decrease of £45. The total receipts for the first half-year of 1894 show an increase of £519 compared with those for the corresponding period of 1893.

Bristol.—University College is shortly to be lighted by electricity. The installation will consist of a dynamo and 200 incandescent lamps. The contract has been let to Messrs. F. W. Ball

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and Co., of Unity-street, Bristol, who have carried out similar work at the Cathedral, the Council House, and other buildings.

Leeds.—Leeds Parish Church is to be lighted by electricity. The plans and specifications have been prepared by Messrs. Shepherd and Watney, Albion-street, and the work will be carried out under their supervision by Messrs. Laing, Wharton, and Down, whose tender has been accepted. The total cost will be about £500.

Coventry.—It is reported that a start has been made towards getting the Coventry and district tramways in working order. The Electric and General Contract Corporation, Limited, have accepted the tender of Mr. Charles Haywood, jun., of 23, Gosford-street, Coventry, for the erection of a generating station and depôt at Foleshill.

Montrose.—Last week the Montrose Town Council visited Kinnaber Waterworks and opened an installation of the electric light there. The power is obtained by means of a water motor driven by the surplus water, and the whole of the extensive works, together with the engineer's residence and outhouses, have been lighted.

Binns's Gas and Oil Engine Company, Limited.—This Company has been registered with a capital of £2,000 in £1 shares. Its object is to acquire as a going concern the business hitherto carried on by Binns and Co. at Halifax, Yorkshire, and to carry on business as gas and mechanical engineers, ironfounders, electrical engineers, etc.

Aberdeen.—The Forsyth Hotel, Aberdeen, has been fitted with the electric light. The installation, which is the largest which has yet been made in connection with the Corporation, consists of over 200 lamps of 16 c.p. each. The work was carried out by Mr. A. G. Emslie, plumber, Rose-street, and Mr. M. Walker acted as consulting engineer.

Sheffield.—The Sheffield Electric Light and Power Company have commenced the work of laying underground mains westward. The work has been started at the monolith, up to which point the mains have already been laid, but work in addition is to be commenced at Ranmoor and in Division-street, so that operations may be completed as soon as possible.

Hull.—The Corporation during the past year have paid on account of electric lighting a sum of £16,938. 18s., making the total capital expenditure £35,153. 16s. On revenue account the adverse balance of £267. 1s. 1d., which was brought forward in last year's account, has been increased, and amounts to £1,080. 16s. 1d., which will be met by the amounts due from users.

Sutton.—The Local Board have received a letter from the Hove Electric Lighting Company, Limited, addressed to Mr. R. W. Wotton, as to Messrs. Crompton and Co. taking up the electric lighting of the district on such terms as to relieve the ratepayers from any expenditure, and have instructed the clerk to communicate with Messrs. Crompton and Co. upon the subject.

Newcastle-on-Tyne.—At Tuesday's meeting of the Town Council, Mr. Chapman presented the report of the special committee appointed to consider the desirability of the Corporation undertaking the provision of electricity in the city. The report is in favour of the Corporation undertaking this work, and we gave the substance of it in our last issue. The report was received.

Tenders for Aberdeen.—As notified in our advertisement columns, the President and Governors of Robert Gordon's College in Aberdeen are prepared to receive tenders for the following works—namely, (1) the supply of materials and the wiring of Robert Gordon's College; (2) the supply of two 1-h.p. electric motors; (3) the supply of materials and the wiring of Gray's School of Art, Aberdeen.

Wakefield.—The Wakefield Corporation Electric Lighting Bill, asking for leave to bring in a Bill for supplying the city with electric light, although later than the time allowed by the standing orders, has come before the Earl of Morley's Committtee on Standing Orders at the House of Lords. After hearing the explanation of the agents for the promoters, their lordships decided to dispense with the Standing Orders.

Electric and General Investment Company, Limited.—The directors on Monday decided to recommend to the shareholders the payment of a further dividend upon the ordinary shares at the rate of 40 per cent. per annum for the six months ended May 31 last (making, with the interim dividend of 10 per cent. already paid, 25 per cent. for the year), and a dividend on the founders' shares of £30 per share for the year.

Tenders for Newcastle-upon-Tyne.—Tenders are invited for telephonic apparatus for communication with the workhouse, for the Guardians. Forms of tender will be supplied at the clerk's office, where specifications and conditions may be seen. Tenders, endorsed "Telephones," must be sent to Mr. John W. Gibson, clerk to the Guardians, Union Offices, Pilgrim-street, Newcastle upon-Tyne, by 12 noon on 22nd inst.

Plymouth.—The Board of Trade Provisional Order Bill empowering the Corporation to generate electricity and supply the current through mains by meter to consumers, has passed the Examiner in the House of Lords on Standing Orders, and has been ordered to be reported for second reading. The mains are to be laid within two years of the passing of the Act in George-street, Bedford-street, and Old Town-street.

West Hartlepool.—At the monthly meeting of the Town Council, with regard to the proposal of the electric tramways company to arrange for lighting of the borough by electricity, Councillor Macfarlane suggested that the matter be confined, for the present, to the running of the tramways. Upon the recommendation of the Works Committee, the agreement with the tramways company was ordered to be sealed.

Bromley.—The Electric Lighting Committee of the Local Board have discussed the question of electric lighting in connection with the suggestion of the Beckenham Local Board that an electric lighting scheme should be worked jointly by the two Boards for the supply of Bromley and Beckenham. Further consideration has been adjourned by the Local Board for more enquiries to be made as to the feasibility of the scheme for a joint station.

The C.C. Concentric System.—Mr. H. T. Barnett, of the London Electrical Goods Agency, 53, Victoria-street, Westminster, recently appointed agent for the Southern district for Messrs. Mavor and Coulson, announces that that firm has now wired the offices of the agency on their C.C. concentric system. The various essential parts are supplied separately, and may be used by any contractor in conjunction with any form of concentric cable.

Glasgow.—On Sunday evening the electric light was used for the first time in St. Bride's Church, Kelvinside. The supply is taken from the mains of the Kelvinside Electricity Company. The contract was carried out by Messrs Claud Hamilton, Limited, to the plans and specifications of Mr. W. Elsdon Dew, resident engineer to the supply company. It is understood that other churches in the district are proposing to adopt the electric light.

Business Change.—Messrs. Binko and Co., of 34, Leadenhall-street, have purchased the goodwill and stock of the firm of Messrs. Ridsdale and Co., 54, Minories, nautical lamp and lantern manufacturers, ships' brassfounders, etc., subsequently carried on by Mr. H. G. Spurgin. They have added this business to their business of manufacturers of electrical supplies for ships' use and domestic purposes, consisting of electric light, bells, telephones, signalling, and other appliances.

Chelmsford.—The electric lighting company have commenced the work of placing the wires underground between the stone bridge and the Red Cow Inn. The electric fire-alarm calls have now been fixed by Messrs. T. H. P. Dennis and Co. at the price of £51. 10s. 8d. A committee of the Town Council is considering the advisability of allowing a telephone company to establish an exchange at Chelmsford in connection with the Government trunk line between Norwich and London.

Ravensthorpe.—The electric light installation at the Self-Help Stores is nearly completed. It comprises externally 18 arc lamps. In the interior of the premises arc lamps have also been fixed. In addition to these, there will be a total of 102 incandescent lights spread about the premises. The entire cost will be a little over £600, including a new engine-house, engine, and dynamo. Messrs. Ullathorne and Hartley, electrical engineers, of Bradford and Halifax, have been entrusted with the work.

Trawden.—The Local Board have received a deputation representing manufacturing firms in regard to the gas supply. Mr. Chester spoke of the serious inconvenience which the manufacturers as well as the weavers were put to during the winter months. They must either have an increased supply of gas or adopt the electric light. A resolution was passed by the Local Board that the clerk should write to the clerk of the Colne Local Board asking them to receive a deputation from Trawden.

The "Aetna" Blow Lamp.—A circular has reached us from Messrs. Moeller and Condrup, of 78, Fore-street, E.C., in reference to the "Aetna" paraffin blow lamp. This apparatus, which the firm states will be invaluable to electricians, instrument-makers, and plumbers, will bring a copper rod to welding heat in a minute, and two copper wires can be joined simply by holding them together in the flame. The firm deal in other types of lamps and stoves, which are mentioned in the circular in question.

Tenders for Oswestry.—Tenders are invited for the supply of engines, boilers, dynamos, switchboard, cables, and conduits for a central station and installation at Oswestry, Salop, for the Oswestry Electric Lighting and Power Company, Limited. Forms of tender and copies of specification, etc., can be obtained from Mr. W. W. Coulson, secretary of the company, Oswestry, Salop, upon payment of £1. 1s., which will be returned on receipt from the payor of a *bonâ fide* tender. Tenders to be sent on or before 16th inst. to the secretary.

Tenders for Mansfield.—Tenders are invited for the erection of a line of poles and overhead wires for the automatic indicating apparatus and telephones between the Rainworth pumping station and the waterworks manager's office at the gasworks, Mansfield, for the Waterworks Committee of the Mansfield Corporation. Plans and specifications may be seen at the office of Mr. George Hodson, M.I.C.E., Bank-chambers, Loughborough. Tenders to be delivered to Mr. R. J. Parsons, town clerk, Town Clerk's Office, Mansfield, by 12th inst.

Hastings.—The secretary of the Hastings and St. Leonards-on-Sea Electric Light Company, Limited, has given formal notice, in accordance with the requirements of Section 14 of the company's provisional order, of the intention of the company to extend their mains. The whole of the mains were specified to be wrought-iron, lap-welded, screwed pipes, to be laid under the pavements where possible, about 12in. below the surface, with cast-iron inspection-boxes, and separate frame and pavement covers at about 40 yards apart were required. The formal approval of the Council has been given to the works.

Greenock.—On Tuesday, at the Town Council meeting, a report was considered from the Town Works Committee on the question of improving the lighting of the Town Hall by the introduction of the Sun burner, fitted with Soleil lamp clusters and reflectors. This report was moved by Mr. Peden. Bailie Cluckie was of opinion that before proceeding with the work they should ascertain the cost of introducing the electric light into the Town Hall. Mr. Hair remarked that, in the face of the fact that the Gas Trust

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was £75,000 in debt, it would be unwise to have the electric light. The report was after further discussion adopted.

Belfast.—The Town Council have adopted the report of the Electric Committee. It stated that considerable progress has been made with the laying of mains, and that tenders for the erection of the central station had been advertised for. The price to be charged for electricity as fixed by the provisional order is not to exceed 8d. per unit, and the committee propose to charge 7d. per unit, with meter rent varying from 2s. 6d. up to 15s. per quarter, according to the capacity of the meter. The committee have accepted the tender of Messrs. M'Laughlin and Harvey, for the erection of the new central electric lighting station in Chapel-lane.

"Slashed" Shell Reflector.—This type of reflector, which has been brought out by Messrs. Faraday and Son, has been designed for lighting a reception-room from the walls in a soft and agreeable manner, chiefly by means of reflected light. The shell is made in hammered brass, finished either in silver, bronze, or gold colour. The lamp bulb is entirely screened from the eye, the light being strongly reflected from the inner plated surface on the walls and ceiling. The piercing or slashing of the shell in the interstices between the ribs is filled with tortoiseshell, talc, or other translucent medium, so that the sombre effect of an opaque reflector is obviated.

Debt for Current.—Last week, at the Guildhall, the United States Land and Investment Company were summoned by the City of London Electric Light Company for the non-payment of £5. 9s. 7d., for the supply of electric current and rental of meter. Mr. G. Kebble, who appeared in support, said this was the first summons under the Electric Lighting Act, and he asked that the order be made with solicitor's costs, as there would be considerable difficulties in the event of non-payments by persons to whom the current was supplied. There was no appearance on behalf of the defendant company, and the Alderman made the order for £5. 9s. 7d. and a guinea costs.

Dundee.—The Finance Committee of the Town Council have been considering the accounts for the past year. At the beginning of last year it was estimated that the expenditure in the electricity department would amount to £3,798. 10s 2d., whereas the actual expenditure was £4,532. 19s. 1d., being a difference of £734. 8s. 11d. The income from electricity was estimated at £2,000, and for meter rents at £35, or a total of £2,035; the actual income being £2,556. 14s. 10d. and £92. 6s. 8d.—total, £2,649. 1s. 6d.—a surplus of £614. 1s. 6d. For the current year the income estimates are: for electricity £3,200, and for meter rents £120, being a total of £3,320. The expenditure is expected to be £5,362. 6s 7d. The estimated deficiency for the year ending April 30 next is £320. 14s. 10d. The price is to be maintained at 5d. per unit.

New Electrical Works at Wolverhampton.—The Public Works Committee of the Town Council have passed the plans for the new works to be erected by Messrs. T. Parker, Limited, on Wednesfield-road. The works are to be of a most extensive character, and will cover four to five acres of ground. The site is immediately opposite the Midland goods station on the Wednesfield-road, and the Midland Railway Company have undertaken to form a siding into the works. The first section of the new works, which will be capable of considerable extension, will consist of a workshop 150ft. by 150ft. In addition to this there will be a foundry, the dimensions of the latter being 120ft. by 40ft, and pattern shops 80ft. by 40ft. Commodious offices will be provided, and these will be uniform in style and design, and in proportion to the works. The architect is Mr. A. P. Brevitt, who has had experience in designing electrical works in provincial towns.

Advance in Quotations.—"Just a week ago," says the *Financial Times* of Saturday, "we referred to the advance which had taken place in the quotations for the stocks of the City and South London Railway Company. Since then there has been a further upward movement, particularly in the price of the 4 per cent. debenture stock, which has risen 5 points to 120. At this price the yield to an investor is only 3½ per cent. The total loan capital authorised is £475,000, and of this there has been issued £95,300 in 5 per cent. debentures, and £97,130 in 4 per cent. debenture stock. The annual interest on these two is a little over £8,600, whereas the net receipts for 1893 were over £16,000, as compared with £13,700 in 1892. Of the 4 per cent. stock, £37,600 was issued in exchange for 5 per cent. debentures, £29,530 for cash, and the balance of £30,000 as security for a temporary loan of £22,000. The two former amounts only are included in the quotation in the official list."

Swan United Electric Light Company.—An extraordinary general meeting of the Swan United Electric Light Company, Limited, will be held at the Cannon-street Hotel, Cannon-street, on Thursday, the 14th inst., at 12 noon, to consider and, if approved, to pass the following resolution, which, if passed by the required majority, will be submitted to a second meeting to be hereafter convened for confirmation as a special resolution—viz.: "That the Swan United Electric Light Company, Limited, be wound up voluntarily, and that Henry Charles Gover, of No. 100, Victoria-street, in the city of Westminster, be, and he is hereby appointed, liquidator for the purpose of such winding up, and that the liquidator be, and he is hereby authorised to carry into effect upon the terms of a provisional agreement between the two companies dated June 5 (subject to any modification), a sale of the Company's undertaking to the Edison and Swan United Electric Company, Limited, for debenture stock of that company to be distributed among the members of this Company."

Manchester.—At Wednesday's meeting of the Town Council, Mr. Alderman Higginbottom called attention to the statements made at a recent meeting of the Manchester and Salford Trades Council to the effect that most of the work done under the direction of the Electric Lighting Sub-Committee had been performed by non-union labour, and at a lower rate of wages than that which was paid to union workmen. The statements had been carefully enquired into, and were found to be absolutely incorrect in every particular. They had nothing, Mr. Higginbottom said, to do with the question whether a contractor employed union labour or non-union labour; all they had to see to was that the standard rate of wages was paid. As a matter of fact, the wages paid were in excess of the standard rate. As to the running of the station, the fact was that instead of there being only two or three persons who received 8d. an hour there were 10. No one received so low a rate as 4d.; the average was 5½d., and in all cases the payment, because of the exceptional nature of the work, was in excess of the standard rate of wages in the district.

Consolidated Telephone Company.—The thirteenth annual general meeting of the Consolidated Telephone Construction and Maintenance Company, Limited, was held last week at Winchester House. Mr. C. L. W. FitzGerald (the chairman), in moving the adoption of the report and accounts, said that in accordance with the resolution passed last year by the shareholders the capital had been reduced. They had paid back to the preference shareholders £27,637 and to the ordinary shareholders 2s. a share, representing £22,485. The capital now stood at 224,850 ordinary shares of 10s each, fully paid. An independent valuation of the plant and machinery showed that instead of £5,300, at which it stood in the accounts, it was actually worth £7,000, so that they had on that nearly £2,000 in hand, under which circumstances the directors considered it unnecessary to write off anything on plant and machinery this year. During the past few months the business had decidedly improved, and although they had hoped to have done better, he thought the fact that they were able to pay the same dividend as last year must be regarded as satisfactory. The motion was carried, and a dividend of 2 per cent. declared, as recommended.

Larne.—At the monthly meeting of the Town Commissioners the clerk read a letter from Mr. Archer Turner, resident electrical engineer, with regard to the hours of lighting, as follows: "With reference to the clause in the new lighting agreement relating to the hour of lighting the lamps, I shall be obliged if you will inform the Board that I have written to and received replies from the electrical engineers of Whitehaven and Weybridge, and from the engineer of the Corporation gasworks, Belfast. The replies from Whitehaven and Weybridge state that they light the town lamps one hour after sunset and that the lamps are all lighted at the same time. The engineer of the Belfast gasworks has kindly sent me the table of time for lighting and extinguishing the lamps, which, on average, is about one hour after sunset for lighting. From the replies you will see that our proposal as to the time of lighting is a very reasonable one, and is more favourable than the plan adopted in the two towns above mentioned which have electric light. I understand the receiver and manager has written you stating the terms on which he would be agreeable to light the lamps from sunset." After some discussion, Mr. Fullerton gave notice of motion for next meeting that he would move that the proposal of the contractors to light from dusk be agreed to.

Gas v. Electricity.—Mr. Henry Coles, electrical engineer, Cardiff, writes to the *Western Mail* as follows: "I note in your issue of Friday last a statement to the effect that the electric current supplied at 6d. per Board of Trade unit is equal, light for light, to gas at 6s. per 1,000ft. On Saturday, in your leading article, you state that the quantity of gas (at 2s. 10d. per 1,000ft.) purchasable for 3·25d. will give an equal amount of light to one Board of Trade unit, which in the instance of Cardiff will cost 6d. Now, are not both these statements rather terrifying to intending consumers, apart from your assurances as to the great economy which works out in practice? The actual facts, as I experience them, are these: A 16-c.p. incandescent lamp can now be obtained which will consume one Board of Trade unit in 18 to 20 hours. A No 6 Bray's gas-burner in the same time (at 6ft. per hour) will consume 120 cubic feet of gas of varying quality and illuminating power at a cost, therefore (at 3s. per 1,000ft.), of slightly over 4½d., as against the electric unit of 6d. I, though, perhaps, a biassed person, can fully endorse what you say in regard to numerous shopkeepers finding their electric lighting bills rather less than their gas accounts for the quarters previous to the installation of the electric light, notwithstanding the efforts made by the gas interests to push forward numerous so-called 'rivals' and 'substitutes' of their own."

Lighting of Tiverton.—Mr. J. Siddalls, the borough surveyor of Tiverton, states in his sixth annual report for the year ended Lady Day, that in February, 1893, he presented a report on the electric lighting of the town by means of water power, and after consideration of the same the Council decided to let the subject remain in abeyance for a time, with a view, if possible, to some method being devised to commence the work on a smaller scale, involving a less capital outlay at starting, and the town clerk and himself were instructed to attend before the Board of Trade and ask for an extension of time. They had an interview with Sir Thomas Bloomfield, of the Electrical Department of the Board of Trade, on June 29, and after explaining the position of affairs, were informed that the Board would allow the provisional order to run for a further period of one year without any steps being taken by them to revoke the order, on the understanding that at the end of the year some proposal for carrying it into effect should be submitted to them. The committee, after some further enquiries, have recommended the Council to endeavour to ascertain the terms upon which Messrs. Heathcoat and Co. would be willing to sell

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the gasworks to the Council, the committee being of opinion that, providing reasonable terms could be arranged, it would most probably be advantageous to work the two enterprises—the supply of gas and electricity—together from the same works. The Council have adopted the report and referred back the subject for full enquiry to be made on the whole matter, which is now being done.

A Question of Solicitor's Costs.—In the Queen's Bench Division on Monday Mr. Justice Cave and Mr. Justice Collins gave judgment in an application made on Friday in the matter of A. T. Ashwell, solicitor, for an order directing taxation of his bill of costs against the Elmore Wire Manufacturing Company, Limited. The application had been refused by the judge in chambers on the ground that the bill had been paid. The company, in now appealing, urged that there were gross overcharges on the face of the bill which constituted "special circumstances" such as would justify the Court in directing taxation. Mr. Justice Cave, in giving judgment, said that, looking at all the circumstances, the proper conclusion appeared to be that the payment of £500 was not a settlement of the bill for £428, the balance going on account of the other bill, but a payment generally on account. He was not satisfied that the items complained of in the bill would amount to "special circumstances," which would justify the Court in directing taxation if there had been a settlement. No doubt a good many of the allegations of undue charges had been fairly explained away in the affidavits, although there were one or two items which it was reasonable to suppose might be reduced by the taxing master. Further, there were indications in the bill itself that it had been hastily prepared, and admittedly one or two items had been wrongly inserted. Under those circumstances the Court thought the best plan would be to send the bill for taxation, the costs of the present application to abide the result of the taxation.

Lighting at Cardiff.—A Cardiff paper states: "The Corporation have now reached the experimental stage in the contest of electricity *v.* gas for public lighting and private consumers. For the former, of course, the town is committed to electricity up to a certain limit, with provision for extension and development later on. Private consumers will need to be convinced that electricity is more advantageous than gas. In the case of those requiring motive power for machinery this may not be difficult, and, probably, shopkeepers will prefer a cool, clean light, without offensive fumes and non-injurious to goods, such as electricity has proved. It is in the case of private residences the rub will come, and it is here people will need to be convinced that electricity is the more advantageous. There is no doubt, light for light and hour for hour, electricity at the price which the Cardiff Corporation propose to charge is dearer than gas. No doubt those who swear by gas are rejoicing at the fact, and hugging themselves in anticipation of the practical collapse of their rival. But the end is not yet. The advantage of electricity, apart from the question of the quality of the light, is in the readiness with which it lends itself to economy of consumption. Gas companies' monopolies are generally most grievous to be borne, and the prospect of relief will be hailed with a good deal of satisfaction by many people. The work of lighting Cardiff by electricity has been going on apace, and at the present time the bulk of the work has been finished. The pipes for carrying the wires, etc., have all been laid, most of the lamps are in position, and the machinery has arrived at the works and is about to be erected. It is almost certain now that the scheme will be carried out about the middle of July next."

Acton.—Mr. T. W. Baker, of Broad-street House, E.C., writes to a local paper as follows: "I notice that the Acton Local Board are advertising for tenders for the transfer of their electric lighting provisional order, and as a 10 years' ratepayer and resident in that district, and having some little knowledge on the matter, I could not well let the opportunity pass without pointing out what I consider will be a loss to the ratepayers if these powers are delegated. It has been always found that a public authority can borrow at a cheaper rate than private individuals, and for these purposes 3½ per cent has been the rate of interest on which loans have been made to other authorities; but another, and I think a far more important, reason exists—that is, the use of the ashbin refuse of the district for generating the steam required for an electricity generating station. Ealing and St. Pancras are just now placing such arrangements in active use, the ashbin refuse being used as merely an adjunct, whereas several other vestries are contemplating it as the main source of heat, coal being supplementary. As the question of dust destruction has been and is becoming a question that the Local Board has to take in hand very shortly, I suggest that it should be taken in hand at once, and by a composite scheme of utilisation, and not only destroyed for the mere destruction, but so as to form a considerable factor in giving the electric light to the locality, with a saving of about 10 per cent. in the cost of that light. There is also no doubt that larger electricity generating stations can be worked more economically than the smaller, and I should suggest that a unified scheme with some other neighbouring authority would be advantageous to both. Being the adviser to more than one local authority on these questions, I have ventured to place my protest against any bartering away of the ratepayers' privileges in this matter of the electric lighting of the district without the subject being maturely considered in all its relations to the welfare of the locality, both in regard to comfort and pocket."

The Exhibition at Dover.—The recent electrical exhibition at the Town Hall, and to which reference was made in our last issue, was a good demonstration of electric light for Dover. The original intention of the Dover Electric Supply Company was to invite the public to come and see the Town Hall lighted for the first time with electricity. Subsequently the idea further developed itself into an exhibition which would show that, in addition, electricity could boil, broil, warm rooms, heat the laundresses' iron, drive a tram, and thrown in were the novel attractions of the telephone and the phonograph. The public exhibition was fixed for Friday and Saturday evening of last week, but a large number of invitations for a private view in the afternoons of those days were sent out, and numerously responded to. The Mayor, Sir William Crundall, chairman of the Dover Electric Supply Company, Mr. Bagshawe, one of the local directors, and Mr. Worsfold Mowll, solicitor to the company, were present to receive the guests. The arrangements for the temporary supply of current were made by fixing in Messrs. Finnis's saw-mills dynamos, which were driven by a pair of horizontal engines. The arrangements were under the control of Mr. W. H. Tasker, the engineer of the Brush Company, who is superintending that company's operations in Dover. Nothing could have answered better, and two or three nights before the exhibition the new light was produced. Perhaps the most demonstrative exhibit was Mr. Holt's electromagnetic car, which on a raised pair of rails was running to and fro with untiring energy. On a stand over his railway Mr. Holt also exhibited an engine driven by electricity. Cooking and heating by electricity was illustrated by numerous stoves, kettles, ovens, frying pans, etc., placed on the platform by the General Electric Company. In another part of the room was a stand supplied from Mr. Webster's Alexander Works, at Folkestone, where electro-plating in gold and silver was going on. Mr. Crofts had on view the Deal dynamo, which he has made for the use of amateurs.

Wrexham.—The minutes of the Council meeting held on April 24, and presented at a meeting last week, contained the following with regard to the electric lighting order. Messrs. Lewis and Son, of Wrexham, wrote to the town clerk as follows: "Your letter of April 3 has been discussed and considered by our board of directors, and we are now authorised to state that with a view of securing this order to the town, although it will be a serious sacrifice to the company, they will accept £350 for their rights in the undertaking, providing this offer be accepted without delay; and, in case it should be declined, that the above price be considered as having been named confidentially and not published." The town clerk having pointed out the difficulty of preventing publication, Mr. Bernard Lewis stated that the condition should be waived. Mr. Murless moved, and Mr. Davies seconded, that the Corporation should accept the offer of the Wrexham and District Electric Lighting Company to sell, at the sum of £350, all rights of and in their undertaking, subject to the transfer of the provisional order, including the vesting by the company (with the sanction of the Board of Trade) and confirmation of all incidental and necessary powers in the Town Council, being carried out by the electric supply company, free of any cost or expense to the Corporation; the matter to be completed within 18 months from this date, but that it be expressly understood that if any insuperable difficulty should be found to prevent the carrying through of the arrangement now proposed, the Corporation reserve the privilege of withdrawing or cancelling this conditional offer without prejudice. This motion was carried. The town clerk read at a meeting of the Council last week a letter from Messrs. J. Lewis and Son, that the directors of the Wrexham and District Electric Supply Company, Limited, would be prepared to fall in with the proposals made by the Town Council, provided the Board of Trade could approve of the same, and would make the costs of transfer light, and suggested that a joint memorial should be signed and sent to the Board of Trade. Alderman Bevan agreed that the costs of the transfer should be made as light as possible, and he thought the method suggested was the proper way to raise the question. He thought the memorial was the right way to raise the question, and moved that the draft of the document, which would have to be sealed, should be submitted to the Council for approval. Mr. Hopley Pierce seconded, and the resolution was carried.

Electric Lighting in Londonderry.—At a meeting of the Town Council last week, the town clerk read Mr. Blake's final report on electric lighting. It stated: "I beg to submit my report upon the working and testing of the works contracted for by Messrs. Alexander Brown and Sons for the street-lighting of Londonderry by electricity. Since March 17 the boilers have been almost continually under steam, and have proved to be well up to the specification in every respect. They have been worked alternately, each boiler being of ample power for the lighting of the city with easy firing and ordinary Welsh steam coal. During the six-hours' test on May 8 and 9 the boilers evaporated 8·75lb. of water per pound of coal, which is a highly satisfactory result. The fuel economiser is entirely in accordance with the specification, and its working is satisfactory. The value of it is clearly demonstrated by the fact that the feed water, by being passed through it, is raised from a temperature of 55deg. F. to 180deg. F., showing a saving of 10·46 per cent. of fuel. The saving would be still greater if the boilers were working under a heavier load. The engines are satisfactory, and in accordance with the specification, which provided for three compound condensing inverted vertical engines, each capable of indicating 100 h.p., at a piston speed not exceeding 450ft. per minute, and with a steam pressure of 110lb. per square inch at the steam-chest, and a vacuum in the condenser of 24in. When officially tested for six hours on May 8 and 9 the average consumption of steam was 18·45lb. per indicated horse-power per hour, or 2·05lb. of coal per indicated horse-power per hour, showing a result better than that provided for in the specification of 25·5lb. of steam, or 2·83lb. of coal per indicated horse-power per hour, which is a saving of over 11 per cent. I consider these engines to be well

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suited for their work; strong and well constructed throughout. I consider this complete duplication of the steam-pipes, with the present position of the engines, an improvement on the ring main; but before adopting it I went to London and consulted Dr. John Hopkinson on the matter, and got his approval of the same in writing. The valves and joints are in good order, and of a class which leaves nothing to be desired. I have no hesitation in saying that Messrs. A. Brown and Sons and Messrs. Siemens Bros. and Co., Limited, have completed all the works in their respective contracts, and also the extras ordered, to my entire satisfaction. I further beg to report that Mr. M. M'Clelland has completed all the works in his contract for erection of buildings, etc., and also the extras ordered, to my entire satisfaction." The town clerk also read the report of Mr. Alex. Craig, mechanical engineer, stating that the Corporation have got useful machinery, capable of performing the required services. Councillor Turner proposed that these reports be adopted, that the Corporation take over the works, and that a sub-committee be appointed to order the extinguishing of such lamps as are not required. Councillor Lane seconded. After some discussion concerning the testing of the plant, the reports were adopted.

PROVISIONAL PATENTS, 1894.

MAY 28.

10228. **Improvements in deodorising and purifying sewage or other waste liquors containing organic matters, in combination with generating and storing electricity, and in means or apparatus therefor.** W. H. Hill-Hartland, 728, Grimesthorpe-road, Sheffield.

10292. **A novel mode of illuminating watches, clocks, compasses, barometers, and similar instruments boxed up in metal cases by means of electricity.** John Manger and Edward Mojon, 26, Bartlett's-buildings, London.

10,293. **A portable electric lamp.** John Manger and Edward Mojon, 26, Bartlett's-buildings, London.

10331. **Improvements in conductors for electrically-propelled tramway and railway vehicles.** Fritz Bernhard Behr, 28, Southampton-buildings, Chancery-lane, London.

10332 **An improvement in regulating apparatus for electric arc lamps.** Sidney John Suter, 28, Southampton-buildings, Chancery-lane, London.

10353. **Improvements in pendant fittings for electric lamps.** John Morris, jun., 40, Chancery lane, London.

10364. **Improvements in electrical devices suitable as meters, motors, dynamometers, and the like.** Emmanuel Dragoumis, 323, High Holborn, London.

MAY 29.

10384. **Improved carbon for electric lighting and other electrical purposes.** George Sheridan Orson, 99, Rugby-avenue, Belfast.

10386. **Improvements in or applicable to clocks for operating electrical lamps.** Ferdinand Fritz, 70, Deansgate, Manchester. (Complete specification.)

10425. **Improvements in electrical transformers.** John Augustine Kingdon, 29, Marlborough-hill, St. John's Wood, London.

10426. **Improvements in dynamo-electric machines.** John Augustine Kingdon, 29, Marlborough-hill, St. John's Wood, London.

MAY 30.

10463. **Improvements in cells or boxes of electric batteries.** John Miles Moffat, 2, Heath-villas, Cargill-road, Earlsfield, London.

10497. **Improvements in electrical measuring and signalling instruments.** Herbert Watson Sullivan, 29, Ladbroke-square, Notting Hill, London.

10490. **Improvements in the method of and apparatus employed for heating steel wire by electric currents.** John Platt, George Hotel, Cleckheaton, Yorks.

10524. **A novel arrangement of screens and shades with means for affixing same to lamps, such as candle, oil, electric incandescent, or other, such screens or shades being adapted for holding and supporting flower sprays or other ornamental objects.** Joseph Henry Rosoman, trading as Smethurst and Co., 166, Fleet-street, London.

MAY 31.

10565. **Phase transformers for electric currents.** Silvanus Phillips Thompson, The Finsbury Technical College, Leonard-street, City-road, London.

10586. **Improvements in wall sockets for electric lighting.** Gustaf Charles Lundberg, 18, Regina-road, Tollington-park, London.

10590. **A combined switch and holder for an electric glow lamp.** The Edison and Swan United Electric Light Company, Limited, and Charles Faraday Proctor, 28, Southampton-buildings, Chancery-lane, London. (Complete specification.)

10594. **Improvements in or in connection with magneto-electrical telephones.** Max Frank, 34, Southampton-buildings, Chancery-lane, London. (Complete specification.)

JUNE 1.

10634. **Improvements on arc lamps.** James William Rogers, 7, Hargrave-park, Upper Holloway, London.

10658. **Improvements in electric chimes.** Frederick William Golby, 36, Chancery-lane, London. (Albert Neumann, Germany.) (Complete specification.)

10659. **Improved apparatus for the suspension of incandescent electric lamps.** Frederick William Golby, 36, Chancery-lane, London. (Albert Neumann, Germany.) (Complete specification.)

10660. **Improvements in or relating to incandescent electric lamps.** Frederick William Golby, 36, Chancery-lane, London. (Albert Neumann, Germany.) (Complete specification.)

10672. **An improved device for casting electric accumulator plates.** Carl Hampel 6, Lord-street, Liverpool.

10687. **An improved electric fire-alarm apparatus.** Louis Borel, 40, Chancery-lane, London.

10701. **Improvements in electrical connections for marine purposes.** Charlas Scott Snell, Culver-park, Saltash, Cornwall.

JUNE 2.

10745. **A continuous-magnetic motor.** Isaac Carruthers, 17, Lower Rock-gardens, Brighton.

SPECIFICATIONS PUBLISHED.

1893.

10298. **Dynamo-electric machines.** Sayers.

11184. **Electrical communication.** Siemens Bros. and Co., Limited. (Morgan and another.)

12786. **Electric arc lamps.** New and Mayne.

13064. **Electric cables.** Thompson.

13218. **Secondary electric batteries.** Lithanode and General Electric Company, Limited, and Niblett.

13274. **Plates for electric accumulators.** Rousseau.

13469. **Electrical railway signals.** Aspinall.

13647. **Galvanometers.** Menges.

13792. **Electric switches.** Clariot.

1894.

2048. **Dynamometers.** Voigtländer.

4244. **Overhead electric tramways.** Dickinson.

7307. **Electrical alarm.** Balbiani.

COMPANIES' STOCK AND SHARE LIST.

Name.	Paid.	Price Wednesday.
Birmingham Electric Supply Company	5	5½-5¾
Bournemouth Electric Company	—	—
Brighton and Hove Company Original	100	210-215
Brush Company, Ordinary	3	2¾-3
—— Nom. Cum, 6 per cent. Pref.	2	2¼-2⅜
—— 4½ Debenture Stock	100	108-111
Charing Cross and Strand	5	4¾-5¼
Chatham and Rochester	—	—
Chelsea Electricity Company	—	—
City of London, Ordinary	10	12-13
—— 6 per cent. Cumulative Pref.	10	13¾-14
—— 5 per cent. Debenture Stock	75	83-85
City and South London Railway, Consolidated Ordinary	100	33-35
—— Debenture Stock	100	117-119
—— 5 per cent. Pref. Shares	10	11½-11¾
Crompton and Co., 7 per cent. Cum. Pref. Shares	5	3-3½
—— 5 per cent. First Mortgage Debentures—1-400 of £100 and A, 1-200 of £50	100	95-100
Elmore's French Company	2	¼-½
Electric Construction, Limited	2	¾-1
—— 7 per cent. Cumulative Pref.	2	1¼-1½
Elmore's Copper Depositing	2	1½-1¾
Electricity Supply Company for Spain	5	—
Elmore's Wire Company	2	1-1¼
Fowler-Waring Cables	5	¼-1¼
W. T. Henley's Telegraph Works, Ordinary	10	6¾-7¼
House-to-House Company	5	1-1¼
India Rubber and Gutta Percha Works	10	23-24
—— 4½ per cent. Debentures	100	103-105
International Okonite, Ordinary	10	1-2
Kensington and Knightsbridge	5	4¾-5¼
Liverpool Electric Supply, Ordinary	5	6¼-6¾
—— Pref.	4½	5¼-6¼
Liverpool Overhead Railway	10	8¼-8¾
—— 4 per cent. Mortgage Debentures of £100	100	110-112
London Electric	5	¾-1⅛
Metropolitan Electric Supply	10	7⅛-8
—— 5 per cent. Reg. Debentures, 1-10,000 in Bonds of £10, £20, and £40	—	108-111
National Telephone, Ordinary	5	4¾-5¼
—— 6 per cent. Cum. First Pref.	10	15-16
—— 6 per cent. Cum. Second Pref.	10	14¼-15¼
—— 5 per cent. Nom. Cum. Third Pref.	5	5¼-5¾
—— 4½ per cent. Deb. Stock	—	114-116
Notting Hill Company	10	4¼-5¼
Oriental and Electric Company, £1 shares	1	1-1½
Southampton Electric Company	—	—
St. James's and Pall Mall, Ordinary	5	6¾-7¼
—— 7 per cent. Pref.	5	8-8½
Swan United	2½	2-2¼
Telegraph Construction and Maintenance	12	39-41
—— 5 per cent. Bonds	100	104-107
Westminster Electric Supply, Ordinary	5	6¼-6¾
Yorkshire House-to-House	4½	4¼-4¾

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NOTES.

Bischoflak.—This town is to receive the electric light by August 1 next.

Madras.—The new post office and other public buildings are to be lighted by electricity.

Electric Lighting at Lyons.—The gas company are extending their electric lighting mains.

Antwerp Exhibition.—The machinery building was formally opened on Tuesday by King Leopold.

Telephony at Bordeaux.—Complaints are being made that the telephonic service is deplorable.

Society of Arts' Conversazione.—This will be held at the Imperial Institute on the evening of Friday, 22nd inst.

Long-Distance Telephony.—Telephonic communication is to be established between Munich, Leipsic, and Berlin.

Junior Engineering Society.—On Saturday, the 16th inst., at 4 p.m., the Wembley Park Tower works will be inspected.

Soleureville.—The Communal Council is in negotiation with Messrs. Siemens and Halske for the supply of electric current.

Electric Lighting at Rochechouart.—A local company is being formed to establish a central electric lighting station here.

New Electrical Workshop.—A new electrical workshop for students is to be established in Paris in connection with the Ecole Diderot.

Ship-Lighting.—The new torpedo-boat destroyer, the "Hornet," tested on Saturday, is equipped with a complete electric light installation.

Geneva.—A proposal is under consideration for the construction of an electric tramway between Champel and Petit-Saconnex *viâ* Geneva.

Rapid Transit in New York.—A Bill has now been passed which will facilitate rapid transit in New York by the aid of electric traction.

Saint-Claude.—M. Passot, an electrical engineer, has applied to the Municipal Council for authority to establish a central electric light station.

North of England Institute of Mining Engineers. A general meeting will be held in the Grand Hotel, Whitehaven, on Thursday next.

Telegraphy in Turkey.—The Turkish Government have ordered the publication of a manual of telegraphy in Turkish for its telegraphists and the public.

Niedersedlitz.—Messrs. Krummer and Co. have projected the construction of an electric tramway from Niedersedlitz *viâ* Kreischa and Lungwitz to Maxen.

German Emperor.—The German Emperor has just had constructed a carriage which is lighted by electricity, and electric lamps are also fixed to the harness.

Basle.—The Municipality have decided to construct an electric tramway between the Baden railway station and the Central railway station at a cost of £28,000.

The Alhambra.—The grand circle has been transformed into a very pretty promenade, and electric lighting assists in enhancing the effect of the decorations.

Meters in Austria.—Measures are being taken by the Austrian Minister of Commerce with a view to the introduction of a standard system of electricity meters.

Islington.—The annual report of the Islington Vestry contains a historical account of the steps taken by the Vestry up to the present in regard to electric lighting.

Traction in Hamburg.—It appears that since the local tramway company introduced electric traction on their lines the gross receipts have very considerably increased.

Schwanenstadt. — Messrs. Siemens and Halske, Messrs. Ganz and Co., and the Oerlikon Works are preparing estimates for an electric light station for this town.

Traction at Konigsberg.—The Union Electricity Company are negotiating with the Königsberg tramway company with a view to the introduction of electric traction.

Calcutta.—The governing body of the United Service Club have decided to light the club premises by electricity. The work will be carried out by Messrs. Octavius Steel and Co.

Railway Station Lighting in France. — The Northern Railway Company are going to light the whole of Creil Station, with the exception of the waiting-rooms, electrically.

Central London Railway.—The Bill, which grants an extension of time until 1900 within which to construct the Central London Railway, has now been sanctioned by both Houses.

Trautenau.—The Municipality have commissioned Messrs. Siemens and Halske, of Vienna, to establish a central station for the supply of 3,000 16-c.p. lamps on the three-wire system.

Crimmitschau.—A projection is on foot for the erection of a central electric light station here. Promises have been received for 56 arc lamps, 3,665 incandescent lamps, and 29 electromotors.

Exhibition at Cardiff.—A fine arts, industrial, and maritime exhibition is to be held in Cardiff next year. Mr. Councillor T. H. Riches is the chairman of the machinery and electricity section.

Worthing.—The expenses of the Town Council in connection with the Hermite tests have totalled £168. 16s. It will be remembered that £200 was the limit fixed by the vote of the Council.

Electric Tramway at Lomberg.—The greater portion of this line has been completed and opened for traffic. The work has been carried out by the Union Electricity Company, of Berlin.

The Great (?) Unknown.—It appears that a man has been stealing electricity in Berlin. If it had been sheet lightning it would not have mattered, but it seems that this is unknown in that city.

The Pollak Accumulator.—A company has been formed under the title of the Akkumulatoren Werke System Pollak, at Frankfort-on-the-Maine, to acquire the business carried on hitherto by Messrs. C. Pollak and Co.

Electric Tramway in Switzerland.—The projectors of a tramway between Hirslanden and Grüningen, in the canton of Zurich, have decided to adopt electric traction, with a generating station on the Forch.

Wiring of Ships.—We note that the committee of Lloyd's Registry are contemplating substituting definite rules for the wiring of ships in the place of their former suggestions, and that they are now drafting such rules.

Iglo.—A local company have concluded a contract with Messrs. Siemens and Halske, in Budapest, for the erection and equipment of a station which is to supply 2,500 incandescent lamps. The work has already been commenced.

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Binningen.—The introduction of the electric light into this Swiss town seems to be assured. There have already been secured a sufficient number of subscribers, and others are expected. The price per lamp is to be 2d. per hour.

Electric Light at Holzkirchen.—The local authorities have decided to erect a central electricity station, utilising the water power of the Mang Fall. The electrical part of the installation will be carried out by Herr Oskar von Miller.

Institution of Engineers and Shipbuilders.—The annual excursion of the members of the North-East Coast Institution of Engineers and Shipbuilders will take place on July 19, when the works of the Consett Iron Company will be visited.

Lightning.—It appears that the members of the Italian fire brigade are very prompt in responding to alarms of fire. According to an illustration in *L'Elettricità*, the firemen arrive at houses struck by lightning before the lightning flashes disappear from view.

Tenders for Electric Tramway.—The Communal Administration of Jekaterinsdar (Government of Kouban, Russia) will receive up to July 25 offers for the establishment of tramways for either electric or mechanical traction in the town of Jekaterinsdar.

Electric Lifts at Berne.—It is proposed to construct electric lifts, so as to facilitate access to the higher parts of the town, which are about 100ft. above the lower parts. The lifts are to have a capacity of 1,900 persons per day. An 8-h.p. electromotor will be employed.

Technical Education in London. — We have received a copy of the annual report for 1893-94 of the Technical Education Board of the London County Council. The report may be obtained from Mr. E. Stanford, 26 and 27, Cockspur-street, Charing Cross, S.W.

Exhibition at Geneva.—A National Swiss Exhibition is to be held at Geneva in 1896. The thirty-eighth section—industrial electricity—will have M. d'Everstag as president, Prof. Denzler, of Zürich, and Prof. Palaz, of Lausanne, as vice-presidents, and M. Cuenod as secretary.

Salzburg.—The capital of the Salzburg Electricity Works, which had already been raised from 500,000 florins to 600,000 florins, has now been increased to 1,000,000 florins. The central station now supplies current to 6,400 lamps, and further 1,000 are to be connected.

Long-Distance Transmission of Power.—The Italian Society for the Protection of National Industry are bestirring themselves with a view to the introduction by the Government of regulations for the promotion of the electrical transmission of power over long distances.

Electric Vehicles.—More attention is being paid in the United States to the question of self-contained electric vehicles. Mr. G. R. Cummings, of Chicago, is demonstrating an electric carriage which is claimed to run at 10 miles an hour, with an expenditure of from 1¼ e.h.p. to 2 e.h.p.

Boiler Incrustation.—The use of petroleum as a means of preventing boiler scale in boilers has been tried for some time in Germany. Mr. Vogt, in the annual report of the Bergisch (Rhenish-Westphalia) Boiler Society, writes deprecating its employment on account of the damage done to the boiler plates.

Central Station at Frankfort-on-the-Maine.—The buildings are well advanced, and ready for the iron roof. The foundations for the boilers and engines are in process of building. The new central post office will only be partly lighted by electricity, to the extent of about 700 incandescent lamps and a number of arc lamps.

The Pacific Cable Question.—Mr. Mercer, of the Colonial Office, has been appointed as a delegate to act in conjunction with Lord Jersey at the Ottawa Commercial Conference, where the question of the proposed all-British-Pacific cable is to be discussed next week. Lord Jersey and Mr. Mercer left yesterday for Ottawa.

Electric Lighting at Vienna.—It is proposed to adopt the electric light at the Vienna University, for the Mineralogical Institute, the Mineralogical Museum, the Geological Institute, the Geographical Institute, and the Chemical Institute. Herr Ernest Heinrichs, the building inspector of the university, has drawn up the plans.

Traction in Switzerland.—A central station is to be erected at Wynau by Messrs. Siemens and Halske, and a scheme is being discussed for the laying down of an electric tramway between Langenthal and Huttwyl. At Oensingen a proposal is under consideration for the construction of an electric tramway to connect that town with Balsthal.

Indiarubber in Ecuador.—The British Consul at Guayaquil states that the production of indiarubber is slowly declining, owing to the reckless manner in which whole groves of these valuable trees are being cut down. No provision for future needs is being made by the planting of young saplings, as in other rubber-producing countries.

Lighting at Caen.—The central electric light station at Caen was to have been set in operation last Saturday. This station has been carried out by the Compagnie Nationale d'Electricité (Ferranti) on behalf of the Société Régionale d'Electricité. The journal *L'Electricien* promises to give a description of the station in its issue of June 16.

Sparrows and the Electric Light.—The inspector of electric lighting reported this week to the Bath Surveying Committee that a lamp in Hall-street had failed temporarily through a sparrow's nest having been built in a pipe through which the wires were taken. The nest had become sodden with wet, and saturated the covering of the wires.

Electricity in Mining.—In the course of his presidential address before the Federated Institution of Mining Engineers last week, Mr. Arthur Sopwith said that electrical transmission of power was a distinctly recent feature in mining, but it was not too much to say that it had been brought up in line with its old-fashioned competitor—compressed air.

Traction at Newcastle.—A meeting of the Town Improvement Committee was held on Friday for the purpose of considering the recommendation of the Tramways Committee embodied in the report of the city engineer, which was given in our last issue. It was agreed to recommend the adoption of the cable system for running the trams.

Engineering, Shipbuilding, and Metal Trades.—A conference will be held at the County Hall, Spring-gardens, S.W., on Wednesday next, to discuss the subject of technical education in its relation to the engineering, shipbuilding, and metal trades. The chair will be taken at 8 p.m. by Mr. Sydney Webb, chairman of the Technical Education Board of the London County Council.

Lighting at Interlaken.—The local lighting company are just completing a small central station. There are laid down two turbines, each of 175 h.p., and one of 25 h.p.; the former will actuate two alternating-current machines, and the latter the dynamo for the supply of the exciting current. The principal railway station and the districts of Matten and Unterseen will be electrically lighted.

Gas v. Electricity.—In connection with the electric lighting of Newport, Monmouthshire, the *South Wales Daily*

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News says that "The Newport Gas Company, as a counter-blast, are sedulously pushing the Welsbach patent gas-burner. Gas as an economical cooking agent evidently has a great future before it, but as a light producer under existing conditions it cannot be said to be long-lived."

Petroleum-Engine Competition.—A competitive test of petroleum-engines has been opened and closed by the Société d'Agriculture of Meaux. We note that a medal has been awarded to Messrs. Griffin and Co., of Bath, for their engine, and that honourable mention is made of the engine made by Messrs. Hornsby and Sons, of Grantham, both being made through the Paris agents of the two firms.

Royal Meteorological Society.—An ordinary meeting of this society will be held at 25, Great George-street, Westminster, on Wednesday next. Papers on the following will be read: "Fogs Reported with Strong Winds during the 15 Years 1876-90 in the British Isles," by Mr. Robert H. Scott, M.A., F.R.S.; and on "Some Characteristic Features of Gales and Strong Winds," by Mr. Richard H. Curtis, F.R.Met.Soc.

Alais.—The question of introducing the electric light into this town has been under consideration for some time. The local authorities have laid down certain stipulations for the concession, and these have been accepted by Messrs. Louche, Bonnefoy, and Froment. The gas company has been notified as to this, and will now have to decide definitely whether they will exercise their prior right to provide the electric light.

The "E. E." Up to Date.—The brief summary given by our correspondent in another column of the proceedings at the meetings last week of the two principal electrical societies in Germany is very interesting. We always endeavour to give our readers bright, practical, readable, and up-to-date information, and we tender them our sincere thanks for the many kind letters of appreciation of our humble efforts in this direction.

Strassburg.—In our last issue we referred to the position of the project for the electric lighting of this city. The firms competing are the Bremen Union, the Frankfort Electrical Works, Messrs. Siemens and Halske, the Helios Company of Cologne, and the Berlin Electricity Company. It is proposed to erect a turbine station on the Rhine. It is hoped that the works will be completed by the time of the exhibition next year.

The Paris Exhibition.—The first meeting of the 1900 Exhibition Commission took place on Friday under the presidency of the Minister of Commerce, M. Lourties. The fourth group is "The *Matériel* and General Processes of Mechanics," including steam-engines, motors, divers apparatus of general mechanics, and implements. The fifth group deals with electricity, including the production and mechanical application of electricity, electro-chemistry, electric lighting, telegraph, and telephone.

Vevey-Montreux.—The report of the directors of the Société Electrique de Vevey-Montreux for 1893 shows that the number of passengers carried on the tramway was 1,309,240, or an average of 3,586 per day, the total receipts being 225,322f., or, say, £9,013. On December 31 last the company supplied current to 9,032 incandescent lamps and 35 arc lamps. The receipts amounted to 187,835f., or, say, £7,513. The total net profit amounts to 146,406f., or, say, £5,856. A dividend of 5 per cent. has been declared.

High-Speed Steam-Turbine.—Our Italian contemporary, *L'Elettricità*, in its issue of June 10, states that the Oerlikon Engineering Works have constructed a Laval steam-turbine coupled to a 5-h.p. dynamo. The same journal says that the speed of the turbine reaches the remarkably high rate of 30,000 revolutions a minute, and that of the dynamo 3,000 revolutions. The efficiency of the dynamo during the first tests is given as 85 per cent., and the consumption of steam per horse-power hour at 15·7 kilogrammes (34½lb.).

Znaim.—The three-wire system of distribution is to be adopted in this Moravian town, where, as we have already stated, a central electricity station is to be erected. A site has been chosen in the north-eastern part of the town. There will be space for four Babcock and Wilcox boilers, and for four 65-kilowatt Siemens and Halske steam dynamos; but to begin with, only two boilers and two engines and dynamos will be installed. Two batteries, each of 68 Tudor cells, will be employed. Overhead conductors are to be used. The installation is to be completed by November next.

Silvertown Dynamos.—A new list of the various types of Silvertown dynamos made by the India Rubber, Gutta Percha, and Telegraph Works Company, Limited, has reached us. These generators are all of the continuous-current type, and those illustrated in the list are the company's standard types for incandescent lighting. They are arranged for belt driving, but slow-speed dynamos for direct coupling, high-pressure dynamos for the transmission of power, and special machines for arc lighting, electro-deposition, smelting, etc., are also constructed by the company. The Silvertown dynamos are so well known as scarcely to need any recommendation; they are made of powers ranging from 3 b.h.p. to 76 b.h.p.

Electrical Communication with Lightships.—In the House of Commons last week, Mr. Bryce said, in an answer to Mr. FitzGerald, that in the last financial year £10,000 was placed at the disposal of the Board of Trade for the purpose of effecting electrical communication with light-vessels, etc. That money was expended in connecting the Kentish Knock and Goodwin (N. Sand Head) light-vessels and the Gunfleet pile lighthouse with the shore. In the present financial year £11,000 had been similarly placed at the disposal of the Board of Trade, and it was intended to expend this amount in connecting the Haisborough and the Shipwash light-vessels with the shore and in laying a cable to the Tuskar Rock lighthouse. The other works recommended by the Royal Commission must, he was afraid, wait until the Treasury could place more money at his disposal

Electrical Engineering in Siam.—In the course of a paper read last week before the Society of Arts, Mr. C. Stuart Leckie stated that the most popular local company in Bangkok is the tramway company, the management of which has been in Danish hands from the commencement. When the success of the concern was proved, the directors replaced the pony cars by heavier electric cars. An American firm got the orders for this installation, and the work seems to have been well done, judging from the regular working for the first year. The directors are well satisfied that they have obtained greater efficiency and greater economy by introducing electric power. Cheap fuel for driving the generating plant is obtained from the sawdust from the neighbouring teak mills. Another company in Bangkok is the electric light company, with a splendid lot of machinery costing £50,000. The lighting has been delayed for a few years by financial difficulties, and matters are at a standstill.

Demonstration of Electric Cooking.—A demonstration of the use of electricity for cooking and heating purposes will be given to-day (Friday) by the City of London Electric Lighting Company at the Cannon-street Hotel, on the occasion of a dinner given by the directors of the company. The Lord Mayor and sheriffs will be

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present at the dinner, which will be cooked by electricity. This step on the part of the City of London Company has doubtless been taken with a view to increasing the day load. There is a large field for the introduction of electric heating and cooking in the numerous City restaurants and cafés, whilst a fair scope, apart, of course, from lighting, is afforded the company in the direction of inducing the large business firms to adopt the electric heaters specially for use during the winter months. The directors of the City of London Company are to be congratulated upon having started this movement in the City, and we trust that their efforts will meet with success.

New Electric Light Regulations.—The following misleading paragraph is being published in numerous provincial papers: "Mr. Francis Hopwood, assistant secretary to the Board of Trade, has issued a circular letter notifying that the electric light regulations, dated July 6, 1891, are revoked, and promulgating new regulations and conditions for the safety of the public, and for ensuring a proper and sufficient supply of energy. In regard to the question of safety, it is provided that only a low-pressure supply shall be delivered to consumers, except in cases specially approved of by the Board of Trade. Various precautions are enforced as to maximum current and local heat, lightning protectors, and the enclosure of high-pressure conductors, continuous insulation, and the detection of leakage. Penalties amounting to £10 a day are specified for contravention of the new rules." We are informed by the Board of Trade that they have not issued any revised regulations for general adoption. The Board have recently approved the system of supply used by the London Electric Supply Corporation, which is slightly different from that formerly approved by the Board, but the regulations issued with the new approval were in no way altered.

The Lyons-Oullins Electric Tramway.—The electric tramway from Lyons to Oullins is the fifth in France where the overhead trolley system has been adopted, and the second in Lyons. The first runs between Lyon-Saint-Juste and Sainte-Foy. The new line, which forms part of the system of the Lyons Tramway and Omnibus Company, is about three and a half miles in length, and the maximum gradient is 3·5 per cent. The line is double for nearly the whole of the route and the curves are easy, but there is a long gradient, which proved very trying to the horses, and up which the cars travelled very slowly. Posts are placed opposite each other on either side of the road, bearing transverse wires, which support the conductors. The central station is near the Oullins terminus, and it is intended to extend the line to Saint-Genis-Laval. The building is in two sections—one containing the boilers and accessories, and the other the steam-engines and dynamos and the car depôt. The boilers employed are of the semi-tubular type, and made by M. Bonnet-Spazin, of Lyons. There are two steam-engines of the Duverger type, made by M. Piguet, of Lyons. They are nominally of 150 h.p., but can give 200 h.p. in case of need. The engines run at 100 revolutions per minute. The electrical plant has been furnished by the General Electric Company, of New York. There are two four-pole dynamos, each of a capacity of 100,000 watts. The rolling-stock comprises 10 cars, capable of each accommodating 40 passengers.

Optical Phase Indicator and Synchroniser.—Before the recent eleventh annual assembly of the American Institute of Electrical Engineers, a paper by Prof. G. S. Moler and Dr. F. Bedell, on "An Optical Phase Indicator and Synchroniser," was read. The apparatus described consists of a device for measuring the angular difference in the position of two shafts running at the same speed. When applied to a synchronous motor, this apparatus shows by direct reading the angle of lag of the armature of the motor behind that of the generator. The authors pointed out, however, that the instrument has a wide application in other lines of work—for instance, the measurement of small speed differences in power transmissions between two shafts, and in work of all kinds where synchronous operation is needed. The motor and dynamo are placed in line with ends abutting in the most simple form of apparatus described. A disc is placed on the end of each shaft. Each disc has a system of slits, and when the slits of one disc cross over those of the other a hole is formed by which light can pass through the two discs. When the discs are revolving synchronously, and a light is placed on one side of the discs, these holes appear as a ring of light. The slits in the discs are so constructed that this ring moves in or out if one disc is revolving more rapidly than the other. The distance of the ring from the centre is proportional to the angle of difference in the positions of the two discs. The apparatus is so arranged that this phase difference may be read directly.

Sterage Battery Phenomena.—In a paper read recently by Mr. W. W. Griscom before the late meeting of the American Institute of Electrical Engineers, the author discussed the question of "Some Storage Battery Phenomena," describing many experimental investigations of storage battery phenomena little understood at the present time. The diverse chemical products formed at different stages of charge and discharge were shown to largely account for the erratic form of the curves of E.M.F., and at the same time it was made manifest that the positive plate at times determines the characteristic curves of potential, whilst at other certain stages the negative plate asserts itself. The curious facts were mentioned that variations of capacities and even of E.M.F. exist in plates identical in history and position, and that one positive may discharge into its neighbour. It was illustrated that the rates of discharge in a cell of the different plates constantly varies in relation to each other. An actual decrease of temperature in a cell discharging was noted and explained as due to the simultaneous lowering of the specific gravity of the electrolyte, and it was indicated that, contrary to usual belief, a positive plate has more capacity than a negative one. Several phenomena for which explanations are wanting were referred to, including the changes shown in internal resistance, the simultaneous increase of internal resistance and potential, the tendency of a charged positive to buckle away from the light, and the sudden spontaneous discharge of a fully-charged positive. The commercial points of the storage battery question were considered, and the lack of success in the United States was attributed to no allowance of a margin of safety in the weight and working of a battery, the observance of which factors has led to success in Europe.

Corrosion of Gas and Water Pipes.—It seems that the Americans are determined to settle the question as to the corrosion of gas and water pipes by electrolysis. The following communication was recently sent by Mr. A. J. O'Reilly, supervisor of the city lighting of St. Louis, to the committee on public buildings and city lighting of the Board of Public Improvements, in reference to a method of ascertaining the results of the electrolysis of water-pipes: "It being desirable to make records of the electrolysis at various places along the water-pipe system of the city that comparison may be made of the relative extent to which the electrolysis is going on during a

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definite time in various parts of the city, and, as this cannot be done with any degree of accuracy with the instruments available for the purpose, without a great increase in the number of observers, the following method has been determined upon by the Water Commissioners and myself. A connection will be made with the water-pipe at convenient stop-valve and fire-plug boxes with a small copper plate of known weight, and placed in the moist earth close to the water-pipe, and allowed to remain there for a definite time, its percentage of gain or loss in weight will be a measure of the current passing to or from the pipe through the plate and into the earth at that place. As a check, a similar test-piece of copper, not connected to the pipe, will be buried close to the other in such a way that it will be subject to the same conditions from action of soil and moisture on the copper which may take place independent of the electric current from the water-pipe. The proper corrections are to be applied on account of the action that may be set up between the iron and the copper independent of the earth return currents under consideration. I am led to believe that, by continuing experiments of this kind and keeping proper record thereof, the affected territory can be definitely circumscribed. The determination of the direction of the street railway return currents must be by voltmeter and ampere-meter methods."

The Influence of Moisture on Chemical Action. Since the publication of a note in the *Proceedings* of the Chemical Society on May 4, 1893, Mr. H. Brereton Baker, M.A., has made further investigations of the actions there mentioned. He finds that sulphur trioxide does not combine with highly purified lime; but a trace of moisture brings about vivid incandescence. Dry copper oxide is also without action on sulphur trioxide. Purified and dried lime does not decompose dried ammonium chloride, which may be sublimed from the mixture without evolving any ammonia. Purified and dried nitric oxide gives no brown fumes with dried oxygen, but a trace of moist air causes them to appear at once. A mixture of purified and dried hydrogen and chlorine can be exposed to daylight for four days without more than three-fourths of the gases combining. Ammonium chloride, heated in a vacuum in a soft glass tube, leaves a residue of ammonia gas; but when dried and heated in a hard glass tube, no gaseous residue is obtained. This led to the investigation of the vapour density of dry ammonium chloride, which was shown to be normal, 28·7 being the mean result of six experiments. With regard to the theory of the subject, the author believes that an electro-chemical hypothesis is applicable. Separation of dried ammonia and hydrogen chloride gases takes place when plates with opposite electrical charges are introduced into the mixture though the action cannot be electrolytic, since discharge is under the circumstances impossible. Similar separation was noticed with air and with a mixture of dried hydrogen and oxygen. Electric discharge, when not of high tension, will not pass in dried gases; but the high-tension discharge does pass, and renders it possible for the low-tension discharge to pass afterwards. With regard to the influence of moisture, it appears that what holds for chemical combination holds also for electrical discharge, and that there is great significance in the apparent similarity in the two cases.

German Fire Insurance Rules.—The regulations issued by the German fire insurance offices for the efficient carrying out of electric light installations in buildings insured by them were, up to the beginning of last year, of a somewhat antiquated character. This fact, according to Dr. O. Gusinde in the *Elektrotechnische Zeitschrift* of May 31, had long been recognised in interested circles, and an alteration was considered necessary. The Society of German Fire Insurance Companies in 1892 took the matter up more seriously, and invited Dr. Oscar May, Dr. C. L. Weber, and Dr. M. Krieg to form themselves into a commission to investigate the subject, and to formulate new regulations for controlling the erection of electric light and power installations. The scheme drawn up by the commission was laid before a meeting of the Society of Fire Insurance Companies in October, 1892, and was adopted, with certain modifications. Dr. May mentioned in the *Erläuterungen* that the work of the commission was based upon the proposals he made at the Electrical Congress in Frankfort in 1891, together with certain alterations. Opinions on the scheme were previously invited from five of the most important electrical firms, who, whilst not objecting to the projected regulations, made certain proposals. The text of the regulations was given on page 307 (1893) of the *Elektrotechnische Zeitschrift*. Several communications published in the latter journal have shown that the regulations have not received the unreserved acceptance of the electrical trades, whilst it has been publicly stated that they would not be generally recognised. It is for the purpose of inviting a general discussion of the regulations that Dr. Gusinde deals with the subject in our German contemporary. After criticising the text of the regulations, the author concludes that he has demonstrated that they cannot be generally accepted. A solution of the problem is necessary, and this, combined with the fact that large electricity works institute regulations of their own, induces the author to hope that the matter will be brought to a satisfactory conclusion.

The Battle of the Cuirasses.—There are now plenty of so-called bullet-proof cuirasses before the public, and the question has arisen as to whether the one or the other contains a metal plate other than steel or iron. With a view to testing this in regard to the Dowe cuirass, the *Pall Mall Gazette* has made an offer in the following terms: "We have devised and erected, in concert with Prof. Silvanus Thompson, F.R.S., the principal of the Finsbury Technical College, an electrical apparatus for proving whether or not the cuirass contains a metal plate, without in any way revealing the actual substance used. The apparatus consists of an induction balance arranged in the following manner: A large circular coil of fine wire is attached to the two poles of an alternating-current dynamo. On either side of this is suspended a smaller coil wound on a bobbin, and connected right and left handedly in series with a telephone receiver. The position of the coils is so adjusted that the currents induced by the central or exciting coil exactly balance each other, when no vibration can be detected in the telephone. If, however, a plate of any metallic substance, whether solid or built up, or constructed of gauze, be inserted between the central coil and either of the side coils, the balance is upset, and a clear ringing note is heard in the telephone. The action is so exact that no mistake can possibly be made, and sensitive enough to enable it to be at once detected whether the disturbance were caused by a large substantial plate or merely by fragments of bullets and steel fragments left inside the cuirass. If Herr Dowe and Captain Martin care to put their cuirass to this perfectly unexceptionable test, the apparatus is at their disposal, and we shall be pleased to invite Mr. Maxim to witness either his own triumph or his own discomfiture, and to collect a competent jury of scientific men and military experts, to be nominated by all parties concerned, in order to see the test fairly performed." The apparatus devised for this test was exhibited at the Royal Society soirée on the 13th inst. It appears that Herr Dowe and Captain Martin have declined to allow the suggested test to take place.

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TWO IMPORTANT MEETINGS OF GERMAN ELECTRICAL ENGINEERS AT LEIPSIC.

(SPECIAL SUMMARY FROM OUR CORRESPONDENT.)

The city of Leipsic presented a festive appearance nearly the whole of last week—from the 5th to the 9th June. One of the reasons for this was to be found in the electrical exhibition in the Crystal Palace, which was opened on Friday, and which will be closed on the 17th inst. As to the exhibition, very little can be written. I may say, however, that it resembles most exhibitions of this kind; it represents pretty fairly the multifarious applications of electricity, and has much of a popular nature about it. Another reason was the fact that great expectations were on foot in anticipation of the visit of the members of two of the most important German electrotechnical societies, who had chosen Leipsic as their place of meeting, one slightly in advance of the other.

Representatives of Electricity Works.

The assembly of the first society—that of the members of the Free Union of Representatives of German Electricity Works (Freie Vereinigung der Vertreter von Deutschen Electricitätswerken)—took place on the 5th, 6th, and 7th. Thirty works were represented, including those of Copenhagen, Christiania, and Stockholm. Dr. Gusinde, of Hanover, presided over the assembly.

The proceedings of the gathering referred more particularly to the working and management of electricity works. Among other matters discussed were the precautions to be observed in the wiring of buildings, the prices charged for current supplied for lighting purposes and that furnished for motive power, the experience gained in working on the three-wire system with an insulated central conductor and with a bare middle wire, and the standardising of electricity and measuring instruments. Finally, the title of the union was changed to that of the Union of Representatives of Electricity Works (Vereinigung der Vertreter von Elektricitätswerken), the proceedings terminating with the election of Mr. F. Jordan, of Bremen, as president for the ensuing year.

Union of German Electrical Engineers.

The meeting of the second society—that of the Union of Electrical Engineers of Germany (Verband der Electrotechniker Deutschlands)—commenced on Friday. It was the second annual meeting; the first gathering in Cologne last year having shown the importance of this semi-commercial semi-technical organisation. The members assembled on the evening of the 7th, in the hall of the Pologne Hotel, where they were welcomed by Herr Lindner on behalf of the local electrical engineers, the address being suitably responded to by Herr Ross, of Vienna.

The opening ceremony of the proceedings took place in the Crystal Palace on the following (Friday) morning, when, in the unavoidable absence of Dr. Slaby (the president), who had suddenly been called away to Berlin, Herr Stübben, of Cologne, occupied the chair. There were about two hundred members present. Herr Georgi (mayor of Leipsic) extended a greeting to the visitors for the Town Council, and Prof. Wislicenus in the name of the university. Then Dr. Wiedemann opened the electrical exhibition in the Crystal Palace. A hasty inspection of the exhibits was made, and, after luncheon, the members of the union settled down—partly to the reading of papers and partly to a detailed examination of the exhibition.

Electro-chemistry of the Future.

Dr. Ostwald, of Leipsic, presented the first paper at the afternoon meeting on Friday, dealing with "The Scientific Electro-chemistry of the Present and the Technical of the Future." The author laid stress on the fact that scientific electro-chemistry as developed in recent years would largely assist technical work in new directions. After dealing with the question of electrolytes, the speaker stated that an improvement in thermo-dynamic machines was only possible in one way—namely, by working with higher starting temperatures. How that was to be accomplished must be left to technical men, but it might be remarked that a solution appeared to lie in the direction of gas motors. If it was possible to transform in some manner or other the chemical energy of fuel—in which the question of heat was left out of consideration—into mechanical work, they would not be bound to inconveniently high temperatures, and would be able to utilise the whole amount without being compelled to accept those inconveniences in the question of purchase. The solution of this great technical question—the provision of cheap energy—must be found in electro-chemistry, in the sense of some form of galvanic battery which at present could not be imagined.

Single Wire for Several Telephone Subscribers.

Herr F. Ross, of Vienna, then described the "Nissl telephone exchange system," to which you referred a few weeks ago. The object of the system is to reduce the installation cost and working expenses, and the author stated that the method allowed of several subscribers to communicate automatically over a single wire with the telephone exchange without interfering with each other. The principle of the method, as mentioned in a previous issue of your journal, is stated to be as follows: At a certain point to which a single wire has been carried is arranged clockwork mechanism which causes a shaft to revolve. The speed of this shaft is governed by the number of subscribers' instruments to be served. For instance, in the case of four instruments the shaft would make a complete revolution in one minute. On the circumference of the shaft are arranged contact-pieces upon which feathers slide in such a manner that individual subscribers are brought successively into communication with the exchange for a short period; when the shaft is at rest the connection lasts. Each subscriber is enabled to arrest the rotation of the shaft at any moment when he is in communication with the exchange. Similarly, the exchange can stop the revolving of the shaft. The bringing to rest of the shaft is effected by means of a current passing through an electromagnet which actuates an armature, causing a catch to be inserted in the cogs of a spur wheel. Arrangements are provided for indicating both to the exchange and to subscribers which contact is sliding under the feather.

Herr C. P. Feldmann followed with a paper on "Lead Safety Fuses." The first part treated of the calculation of fuses from various points of view; the second dealt with those factors which influence the current strength necessary to melt the fuses; and the third with the faults of fuses, coupled with the suggestion that the union should introduce a standard method of description of fuses.

Rotary-Current Plant and Rectifiers.

Herr W. Lahmeyer, of Frankfort-on-the-Maine, presented a paper on "The Arrangement of Rotary-Current Installations and Rectifiers." The author remarked that the arrangement allowed, on the one hand, of the maintenance of the pressure of the lighting current when a number of electromotors was used, and, on the other hand, an increase in the output of the primary machines. The principle of the method lies in the transmission from the secondary machines to the generators of a variable amount of magnetising current, according to requirements. The system, which allows of motors being practically employed, has been introduced by the Lahmeyer works at Bockenheim, and in the case of the transmission of 300 h.p. from Bozingen to Biel, in Switzerland. At present, two rectifiers of 600 h.p. are in course of construction at the Frankfort works.

Mr. Gisbert Kapp then gave a historical account of the development of electrical engineering in England, and mentioned the reasons that had led to the adoption of the systems of electric lighting employed. In conclusion, he referred to the existing and projected electric railways.

Dr. Carl Feussner, of Charlottenburg, read a communication treating of the Imperial Technical Institute (Reichsanstalt).

Pressure and Current Curves.

Dr. G. Rössler, of Charlottenburg, in a paper dealing with "The Pressure and Current Curves of Various Types

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of Alternators and their Influence upon the Lighting Power of Alternating-Current Lamps," discussed some investigations which he had made, in conjunction with Dr. Wedding, in the electrotechnical laboratory of the Technical High School, in Berlin. The enquiries and tests made were undertaken in consequence of the difficulties experienced with arc lamps in the sense that no matter from which maker they were obtained, when taken to their destination, the lamps either did not burn properly or they would not work at all. In conjunction with the investigations, the author entered into the question as to the illuminating power of alternating-current arc lamps. A comparison between the lighting efficiency of direct-current arc lamps and alternating arc lamps showed the former to be more favourable.

General Business Matters.

Dr. Slaby, having returned from Berlin, presided at the commencement of the proceedings on Saturday, when the general business of the union was dealt with.

Herr Sluzewski, in presenting the second annual report of the union, stated that the number of members was about 800, being about the same as in the previous year.

Among other business transacted was the alteration of the name of the union to that of "The Verband Deutscher Elektrotechniker" (Union of German Electrical Engineers), with offices in Berlin. The union expect to establish a closer connection between German electrical engineers, and to obtain a permanent representation and advancement of German electrical engineering by (1) an annual meeting of the members in some German town, where an interchange of opinions on important questions by means of papers and discussions will be effected; (2) by bringing the members into personal contact; (3) by the efforts of the organ of the union; (4) by publication of a union journal and other publications; and (5) by other means permitted by the available funds of the union.

Mr. Kapp and the "Elektrotechnische Zeitschrift."

The President then reported on the agreement entered into between the Verband Deutscher Elektrotechniker and Mr. Gisbert Kapp, as general secretary to the union, and according to which an annual remuneration of 20,000 marks (£1,000) is guaranteed to Mr. Kapp. The meeting, with a large majority, approved the conclusion of the agreement, and the president welcomed Mr. Kapp as general secretary.

Mr. G. Kapp thanked the members of the union for their confidence in him, and assured them that he would earnestly endeavour to promote the welfare of the union.

The next item on the agenda was the approval of an agreement with the publishing firm of Julius Springer, of Berlin, and R. Oldenbourg, of Munich, according to which the *Elektrotechnische Zeitschrift* (the organ of the Electrotechnical Society of Berlin) now becomes the official journal of the union. This agreement was also adopted.

Prof. Budde, of Hanover, then presented a report dealing with exhibition questions, with special reference to the supply of light and power at the Berlin exhibition, by the intermediary of a syndicate of the union. A similar course is to be adopted in the case of the exhibition to be held at Carlsruhe.

Dr. T. Bruger, of Bockenheim, in a paper on "Some Direct-Reading Measuring Instruments," exhibited and described various forms of instruments.

Herr F. Teichmüller, of Mülheim-on-the-Rhine, read a paper on "The Conductivity of Copper." He stated that the specific conductivity of copper was expressed in so many ways as to lead to confusion. It was desirable therefore that a standard method should be introduced. The basis of a system must be the absolute measuring method, and he concluded with the expressed wish that a commission should be nominated to discuss the question.

Three-Wire System with a Single Dynamo.

Herr von Dolivo-Dobrowolsky, of Berlin, then presented a paper on "Direct-Current Machines on the Three-Wire System." The author described a method of distribution on a three-wire system from a single dynamo, and which was illustrated in your journal on April 13. It is, of course, well known that to establish a three-wire system, a neutral point must be created in the generating system, and to which the compensating wire is connected. It is in the formation of this neutral point that the originality of the system described lies.

Instead of joining two dynamos in series to obtain this result, there are connected to two points diametrically opposed of the armature the two extremities of a coil, having great self-induction and a feeble ohmic resistance. During the rotation of the armature there will be produced between the points an alternating E.M.F.; but as the coefficient of self-induction of the system has a great value, the alternating current created in the circuit will be weak. It is possible to reduce the intensity of this current as much as desired by increasing the coefficient of self-induction of the coil, which can easily be done by arranging it on a core closed in iron.

If the compensating wire, by which the groups of lamps are connected in series, is placed into communication with the neutral point, and if the "bridges" used contain in operation the same number of lamps or apparatus, the neutral wire will remain without current. But if No. 1 "bridge" is loaded more than No. 2, the excess of current of the first over the second will return to the dynamo by the compensating wire, and, reaching one point, this current will be divided. As it is continuous, it will have no difficulty in traversing the coil mentioned so as to penetrate the armature. By the aid of this device, exactly the same conditions as in the case of the use of two generators arranged in series are obtained. The independence of the two consuming groups is complete, and if one or other of these groups consumes more current than the other, the pressures remain the same, since the excess of the current returns to the armature without any loss by the neutral wire and by the coil.

As it is not always practicably possible to revolve the coil with the armature of the dynamo, two diametrically opposed segments of the commutator can be respectively connected to two rings on the shaft, and upon which press two brushes placed in communication with the two extremities of the coil. This coil, which in this case is fixed, is arranged in a box at the side of the dynamo, and always has, as in the preceding case, its neutral point connected to the compensating wire. This method can be employed for the purpose of regulating the pressure, especially in the case where the central station is distant, and supplies current at a pressure equal to the total tension of the two groups of lamps. In this case it is only necessary to insert near the places of utilisation one or several of these dynamos provided with self-induction bobbins. The brushes are put into communication with the main conductors in such a manner that the armature commences to revolve and works as a motor; the neutral wire has not to be connected to the central station situated some distance away, and it then only serves for the compensation of the two circuits in use.

Concluding Proceedings.

Herr E. Naglo, in the course of the proceedings, brought forward the question of tendering for contracts. As a result of this communication the union resolved to appoint a commission to make proposals with a view to devising a method of avoiding the misunderstandings which arise in the invitations for tenders, especially in regard to the working out of costs and schemes.

Herr Carl Dihlmann's motion that the commission nominated for the purpose of introducing a standard size of contacts and screws should be allowed to quietly continue its labours, was adopted.

A discussion having taken place in regard to the Bill proposing certain exceptions to Sunday labour, it was unanimously decided to hold the next annual meeting in Munich in the middle of 1896.

Dr. Slaby having been re-elected president, with Herren Wilhelm von Siemens, Oskar von Miller, and C. Hartmann and Prof. W. Dietrich and Herr Kolle as vice-presidents, the proceedings terminated in a dinner given in the Central Hall.

Mix and Genest.—The new factory of Messrs. Mix and Genest now being built in Bülowstrasse, Berlin, will be completed in October.

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PHYSICAL UNITS.

BY MAGNUS MACLEAN, M.A., F.R.S.E.

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(Continued from page 683.)

§ 9. The unit of time universally employed is a mean solar second. The reader should notice that this unit of time differs from a solar second and from a sidereal second. A sidereal day is the time that elapses between two successive transits of any fixed star at any chosen meridian, or it is the time of the earth's rotation on its own axis. A sidereal second is, therefore, the time that the earth takes to rotate through an angle of one two-hundred and fortieth of a degree.*

§ 10. A solar day is defined as the time that elapses between two successive transits of the sun at any given place on the earth's surface. For two reasons this time is of variable length. Firstly, the path of the earth round the sun is an ellipse, and hence its motion is sometimes quicker and sometimes slower. Secondly, the motion of the earth is in the plane of the ecliptic and not in the plane of the equator.

§ 11. To understand the first cause, Newton's universal law of attraction will help us: "Every particle in the universe attracts every other particle with a force which is proportional to the product of the masses of the two particles directly, and to the square of the distance between them inversely." Take two uniform spheres of masses, m and m^1, and let the distance between their centres be d, then the force of attraction between them is $F = k\frac{m\,m^1}{d^2}$, where k is the mutual force of gravitational attraction between unit masses at unit distance, and its value is calculated below for both the metric and British units.

Now, the mass of the earth is $6{\cdot}14 \times 10^{27}$ grammes, and the radius of it is approximately 637×10^6 centimetres. Hence, if we take the force of gravity on one gramme to be 980 dynes, we get $k = \frac{980 \times (637 \times 10^6)^2}{6{\cdot}14 \times 10^{27}} = 64{\cdot}8 \times 10^{-9}$ dyne $= \frac{1}{15{\cdot}43 \times 10^6}$ dyne.

The force with which two homogeneous spheres of matter of one gramme would attract one another, when their centres are 1cm. apart, is approximately a fifteen-millionth part of a dyne. To find out what would be the mass of two spheres† that would attract with the force of one dyne, when their centres are 1cm. apart, we have $F = 1$, $m = m^1$, and $d = 1$, $\therefore m = \sqrt{1/k} = 3{,}928$ grammes.

If we take the British units

$$k = \frac{32 \times (21 \times 10^6)^2}{13{\cdot}5 \times 10^{24}} = \frac{1}{965{\cdot}7 \times 10^6} \text{ poundal,}$$

and a calculation similar to the above gives the masses that would have one foot apart (see footnote as to a practical problem), a mutual force of attraction of one poundal, as 31,075lb.

§ 12. Let Fig. (1) represent an ellipse, S the sun in one focus, and E the earth. The earth when at A^1 is about three million miles nearer the sun than when at A. Hence the velocity of the earth at A^1* is greater than the velocity at A. In passing from A^1 to A the velocity of the earth is continually decreasing, and in passing from A to A^1 it is continually increasing. (The average velocity of the earth in its path is approximately 18½ miles per second.) At A^1 when the earth is in the winter solstice of the northern hemisphere, the solar day is longer than when it is at A in the summer solstice. That is, a solar day in mid-winter is longer than a solar day in mid-summer. In the further understanding of this fact, one of Kepler's three laws of planetary motion is of great help: "The radius vector of any planet sweeps over equal areas in equal times." In the figure, if the earth takes the same time to pass from A to B as from A^1 to B^1, then area S A B is equal to the area S A^1 B^1.

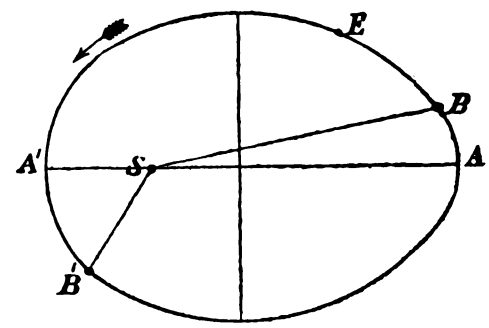

FIG. 1.

The other two laws of Kepler, though not necessary to the present discussion, may be stated here: "The planets revolve in ellipses around the sun, and the centre of the sun occupies one of the foci."

"The squares of the periodic times of any two planets have the same ratio as the cubes of their maximum (mean) distances from the sun."

§ 13. These three laws are purely kinematical. Their dynamical interpretation was discovered by Newton. From the law that the areas swept over by the vector drawn from the sun to a planet are proportional to the times of describing them, Newton inferred that the direction of the force acting must always pass through the sun.

From the law that the orbit of a planet with respect to the sun is an ellipse—the sun being in one of the foci—and, in conjunction with the previous law, Newton inferred that the magnitude of the force acting is inversely as the square of the distance from the sun.

From the law that the squares of the periodic times of different planets are proportional to the cubes of their mean distances, Newton inferred that at the same distance gravity acts equally on equal masses of substances of all kinds.

§ 14. The second cause of the variable length of the solar day is that the apparent motion of the sun, or the real motion of the earth, is in the plane of the ecliptic, and not in the plane of the equator. The angle between the plane of the equator and the plane of the ecliptic is nearly 23½deg. The points in which the sun in his apparent motion cuts the plane of the celestial equator are called nodes. If we suppose an imaginary sun to start from one

* "In our first edition it was stated in this section that Laplace had calculated from ancient observations of eclipses that the period of the earth's rotation about its axis had not altered by 1/10⁷ of itself since 720 B.C. In § 830 it was pointed out that this conclusion is overthrown by farther information from "Physical Astronomy" acquired in the interval between the printing of the two sections, in virtue of a correction which Adams had made as early as 1863 upon Laplace's dynamical investigation of an acceleration of the moon's mean motion, produced by the sun's attraction, showing that only about half of the observed acceleration of the moon's mean motion relatively to the angular velocity of the earth's rotation was accounted for by this cause. (Quoting from the first edition, § 830.) "In 1859 Adams communicated to Delaunay his final result—that at the end of a century the moon is 5″·7 before the position she would have, relatively to a meridian of the earth, according to the angular velocities of the two motions, at the beginning of the century, and the acceleration of moon's motion truly calculated from the various disturbing causes then recognised. Delaunay soon after verified this result, and about the beginning of 1866 suggested that the true explanation may be a retardation of the earth's rotation by tidal friction. Using this hypothesis, and allowing for the consequent retardation of the moon's mean motion by tidal reaction (§ 276), Adams, in an estimate which he has communicated to us, founded on the rough assumption that the parts of the earth's retardation due to solar and lunar tides are as the squares of the respective tide-generating forces, finds 22ˢ. as the error by which the earth would in a century get behind a perfect clock rated at the beginning of the century. If the retardation of rate giving this integral effect were uniform (§ 35, *b*), the earth, as a timekeeper, would be going slower by ·22 of a second per year in the middle, or ·44 of a second per year at the end, than at the beginning of a century." Thomson and Tait, "Treatise on Natural Philosophy"; footnote to § 405, page 460.

† The word sphere is used intentionally, for a uniform sphere attracts external matter as if its whole mass were concentrated at its centre. The problem in the text is unrealisable in practice, but it can be asked what would be the mass of each sphere to have a mutual force of one-hundredth of a dyne, when their centres are 10cm. apart. Thus a sphere of gold weighing 3,928 grammes would be 3·65cm. in radius.

* Centrifugal force is also greater at A^1, but a complete discussion of the problem is not attempted here. The velocity at any point is inversely proportional to the perpendicular from S to the tangent at that point.

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of these nodes at the same time as the actual sun, and to move in the equator with such a uniform velocity as to arrive at the node again at the same instant as the real sun, then time indicated by this imaginary sun is mean solar time. Mean solar second is $\frac{1}{86400}$ of a mean solar day. A solar day is 3 minutes 56 seconds, or nearly four mean solar minutes longer than a sidereal day. Further information on this important subject ought to be obtained by referring to any modern text-book on astronomy.

§ 15. It is evident from § 8 that the choice of a definite length and of a definite mass, as two of the fundamental units, fulfils the most important considerations necessary in their selection. It should be possible to compare them easily, directly, and accurately with other quantities of the same kind, and this at all times and at all places.

§ 16. The unit of time is subject to a slow variation (see footnote § 9), and hence other fundamental units of time have been suggested. In Thomson and Tait's "Natural Philosophy," vol. i., § 406, page 461, the period of vibration of a metallic spring kept at a constant temperature in an exhausted and a hermetically sealed glass vessel is suggested, and the statement is made that "it would almost certainly be more constant from age to age than the time of rotation of the earth (cooling and shrinking, as it certainly is, to an extent that must be very considerable in fifty million years)." In § 223, page 226, it is said that "the period of vibration of a piece of quartz crystal of specified shape and size, and at a stated temperature (a tuning-fork, or bar, as one of the bars of glass used in the 'musical glasses') gives us a unit of time which is constant through all space and all time, and independent of the earth." Other two units of time are suggested in the same article—viz., (1) the time of revolution of an infinitesimal satellite close to the surface of a globe of water, at standard density; and (2) the time of the gravest simple harmonic infinitesimal vibration of the same globe. It is shown that both these units are independent of the size of the globe. Lastly, it has been suggested that the time of vibration of some widely diffused substance, such as sodium or hydrogen, might be taken as the unit of time, and that its wave-length in vacuum might be taken as the unit of length.

"The recent discoveries due to the kinetic theory of gases and to spectrum analysis (especially when it is applied to the light of the heavenly bodies) indicate to us *natural standard* pieces of matter, such as atoms of hydrogen, or sodium, ready made in infinite numbers, all absolutely alike in every physical property. The time of vibration of a sodium particle corresponding to any one of its modes of vibration is known to be absolutely independent of its position in the universe, and it will probably remain the same so long as the particle itself exists. The wave-length for that particular ray—*i.e.*, the space through which light is propagated *in vacuo* during the time of one complete vibration of this period—gives a perfectly invariable unit of length; and it is possible that at some not very distant day the mass of such a sodium particle may be employed as a natural standard for the remaining fundamental unit."*

ON AN APPARATUS FOR THE MEASUREMENT OF COEFFICIENTS OF SELF-INDUCTION, AND THE INVESTIGATION OF THE PHENOMENA OF ALTERNATING CURRENTS.†

BY FRANK A. LAWS.

The increasing use of alternating currents in telephony and electric lighting has during the last few years directed attention to the measurement of coefficients of self induction. In this paper certain apparatus devised for this purpose, together with methods for its use, will be described. Further discussion of the various methods of measurement proposed and of experimental results obtained is reserved for a later article.

For investigations pertaining to telephony it is particularly desirable to measure inductances by means of alternating currents of suitable known frequencies, and of the same order of magnitude as those used in practice. In all such work the reduction of the results is greatly simplified if the E.M.F. employed follows the sinusoidal law.

Therefore the aim at the outset was to produce a dynamo whose E.M.F. should vary in this manner, and whose frequency of alternation should be about that which is normal in telephonic work. Under these requirements there have been designed in the Rogers laboratory two dynamos, or arrangements of dynamos. The first of these was planned during the winter 1890-91, and was used by Mr. L. Derr in connection with his thesis in 1891-92. This machine was provided with a stationary armature having Lord Kelvin's zigzag winding on the outer surface of a hollow cylinder. This was placed in the gap between a star-shaped piece of iron and a disc with a corresponding star-shaped opening, the two pieces being similarly and concentrically placed and forming the pole-pieces of the machine. Owing to the shape of the pole-pieces, the field between them is variable, being denser at the points of the stars, so that when the field moves past the armature an E.M.F. will be set up in the latter.

One disadvantage of this design is that the E.M.F. is small, owing to the very large non-effective field, for it is only the variation of the field that is of service in producing the E.M.F. By properly shaping the pole-pieces a curve of E.M.F. was obtained, which when plotted was found to be nearly sinusoidal in form.

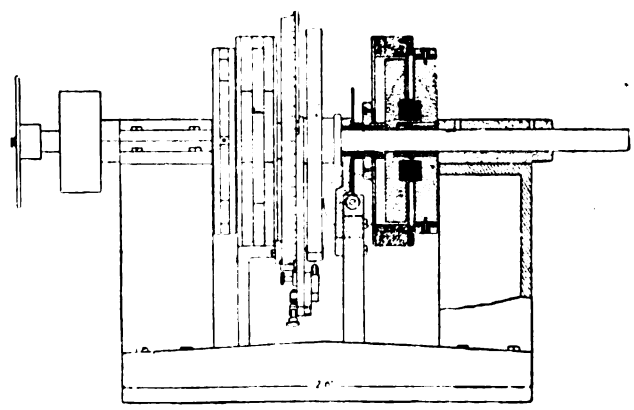

FIG. 1.

The second machine was constructed by Messrs. C. L. Norton and P. H. Thomas, of the class of 1893, and forms the subject of the present paper. The special form of dynamo used was designed in accordance with a suggestion from them. The frequency is somewhat low, being 400 complete alternations per second. When another machine is built it will be so designed that the superior limit will be raised to 2,000 complete periods per second.

Both the machine of 1890 and that of 1892 embody the same general features. Each has two independent armatures—one fixed, the other movable in phase relation to the first. This relation is capable of measurement. At the outset it was determined that in these machines the armatures should contain no iron, and that they should remain stationary, in order to eliminate any possible microphonic action at the brushes.

The machine consists, in brief, of two dynamos, with revolving fields mounted on one shaft to ensure definite phase relation. The armature of one is fixed, while that of the other may be given any desired angular advance or retardation in reference to the first by means of a tangent screw. This advance can be read off from the graduated head of the screw. The fields are independent of one another. In addition to the dynamos the shaft carries a contact arrangement for mapping wave forms, and a stroboscopic disc for determining the speed of rotation.

One of the field magnets is shown in plan in Fig. 2 and in section in Fig. 1. It consists of two star-shaped pieces of cast iron, keyed to the shaft and having hubs of such a

* Thomson and Tait, "Natural Philosophy," § 223, p. 227; see also Maxwell, "Electricity and Magnetism," second edition, vol. i., § 3, and "Popular Lectures and Addresses," by Lord Kelvin, vol. i.; a lecture at the Institution of Civil Engineers on "Electrical Units of Measurement."

† Contribution from the Physical Laboratory of the Massachusetts Institute of Technology.

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length that the faces of the teeth are $\frac{5}{16}$in. apart, thus leaving a gap in which is the armature, $\frac{1}{4}$in. thick. The castings are recessed to receive the field coils, which are about one square inch in section and contain 250 turns of No. 16 B. & S. double cotton-covered wire. The coils were wound on forms, paraffined and taped, and were inserted when the machine was assembled. The terminals are brought out through bushed holes and fastened to composition collector rings, which are carried and insulated by blocks

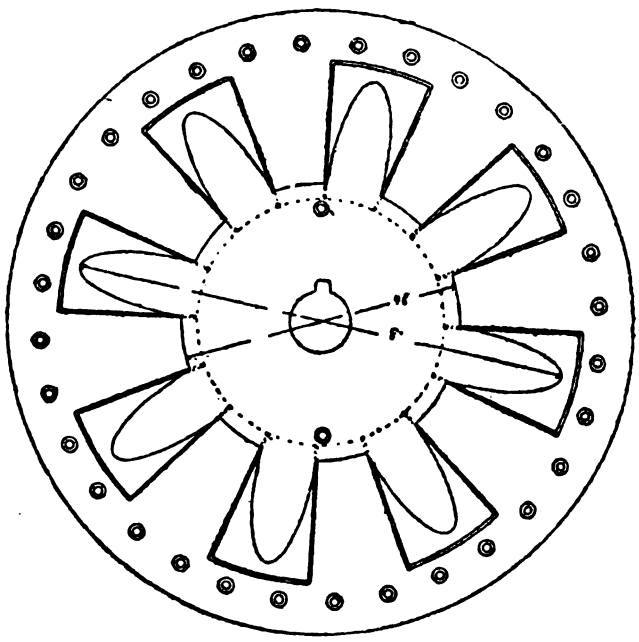

FIG. 2.

of vulcanite mounted on the tips of the teeth of one of the castings. The brushes of spring copper are supported from the base-plate. The eight teeth were milled from the round by a special Brown and Sharpe cutter, and have the form of a sinusoid laid off radially from the base circle. Of course, owing to the spreading of the lines of force, the particular form to be given to the teeth in order to obtain the best action can only be ascertained by trial.

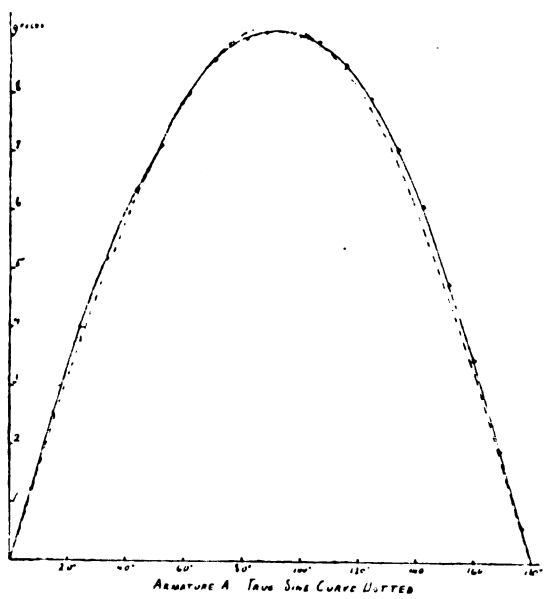

FIG. 3.

The armature consists of a vulcanite disc, 10$\frac{1}{2}$in. diameter, $\frac{1}{4}$in. thick, having a 4in. hole in the middle. From this hole radiate 16 equally spaced saw-cuts $\frac{3}{16}$in. deep, $\frac{1}{16}$in. wide, and 2$\frac{1}{2}$in. long, the outer extremities of alternate pairs of cuts being connected by grooves concentric with the disc. In these cuts and grooves the armature wires are laid in shellac. The windings at present consist of three sections having respectively 10, 10, and 20 turns of No. 30 B. & S. copper wire. The total resistance is about 10 ohms. The manner of winding, as well as the action of the dynamo, by varying the length of active wire, are evident from Fig. 3. The armatures are carried by built up hardwood rings, 10$\frac{1}{2}$in. outside diameter, 8$\frac{1}{4}$in. inside, and 1$\frac{9}{16}$in. deep. The ring in one dynamo is attached to a brass disc and hub, which fit the shaft and are rigidly bolted to the frame of the machine.

In the other dynamo, the armature, ring, disc, and hub are attached to a worm-wheel, and the whole is movable on a sleeve supported firmly from the frame of the machine. Through this sleeve passes the shaft without contact. The worm-wheel gears into a tangent screw provided with a divided head, the gearing being such that 1deg. on the wave form is represented by 20deg. on the head. Backlash is prevented by a spiral spring. See Figures 1 and 2.

Between the two dynamos is a brass disc, keyed to the shaft and provided with an insulated collector ring and contact point. By the side of this disc is a radial arm, revolving freely about the shaft, and capable of being clamped at any desired point to a fixed graduated circle. The arm carries the contact spring, made of watch-spring supported on its lower side very near its extremity to prevent the lengthening of the arc of contact by vibration. The spring can be moved out of contact with the point by a fine-pitched screw. This contact arrangement we have found to work satisfactorily at as many as 3,000 revolutions per minute.

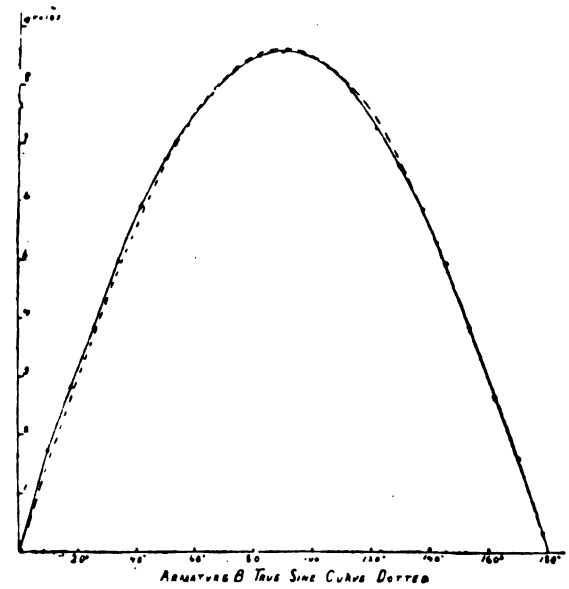

FIG. 4.

The shaft of the machine is of steel, 1in. in diameter, 29in. long, and runs in composition bearings, each of which is 5$\frac{1}{2}$in. long. The frame of the machine is heavy, weighing 175lb., and is designed so as to be very rigid. Driving is effected by means of a 2in. belt running over a 5in. pulley. The motor (1 h.p.) is of the Sprague type. Variations of speed are obtained by the use of pulleys of different sizes on the motor shaft.

Both machine and motor rest on a brick pier, the machine being set in sulphur; mechanically, the arrangement leaves nothing to be desired. It has been run continuously at the rate of 3,000 revolutions per minute, without perceptible jarring.

The machine was at first supplied with a mechanical counter, which could be thrown on or off by means of an electromagnet operated by a key. We found, however, that the arrangement was unsatisfactory, as variations of speed were introduced by its friction and inertia. Moreover, such an arrangement gives only the average speed during a given time; we therefore abandoned this counter and adopted a stroboscopic device. A ray of light is reflected upon the revolving segmented disc from a mirror attached to an electrically driven tuning-fork of known rate. With such an arrangement the desired speed may be attained, and variations from it measured by noting the apparent motion of the disc.

The first test to which the apparatus was put was to obtain the judgment of a person having a trained ear as to the quality of the tone produced by its current in a

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telephone. His opinion was that the tone was pure, only the fundamental being detected. The wave form was then mapped.

In planning this work it occurred to us to employ the method of projection of potential whenever it was necessary to measure a P.D. or E.M.F. at any instant. The opposing P.D. was obtained by the fall of potential due to the passage of a direct current through a suitable resistance. As the opposing P.D. was not alternating, the above-mentioned contact arrangement was used in place of the ordinary key, and its value was determined by a suitable Weston voltmeter. This method of dealing with instantaneous E.M.F.'s was originally suggested by Profs. Foster and Maxwell, their object being to obtain a balance between a known E.M.F. and the P.D. between the terminals of a resistance through which a current of known absolute magnitude was flowing.*

In order to obtain sensitiveness at the final balancing, a condenser one microfarad in capacity was inserted in shunt with the galvanometer, the discharge of the condenser serving to increase the deflection. The galvanometer was of 3,000 ohms resistance. A telephone was used to obtain the preliminary balance. In Table I. are given the results of the determination of the wave forms of both dynamos, one section of 10 wires being used. In the case of armature A (movable) a series of checks is appended. The whole series was gone through with, and then repeated in the reverse direction, the person making the readings not knowing the previous results. The most probable sources of deviation are back-lash, variations of field current, and change of speed. The checks show sufficient precision of the apparatus for the method of procedure to be described presently.

TABLE I.—Determination of Wave Form.

Armature A. Ampere-turns, 2,875. Speed, 1,465.			Armature B. Ampere-turns, 2,150.	
Revs. of Mic. head.	E.M.F. in volts.	Check.	Position of contact.	E.M.F. in volts.
			Deg.	
0	+0·49	+0·48	11	+1·00
½	−0·91	−1·20	10	−0·26
1	−2·52	−2·53	9	−1·72
1½	−4·01	−4·01	8	−2·80
2	−5·21	−5·19	7	−3·86
2½	−6·38	−6·36	6	−4·98
3	−7·09	−7·21	5	−5·93
3½	−8·04	−8·03	4	−6·75
4	−8·61	−8·61	3	−7·34
4½	−9·01	−8·96	2	−7·86
5	−9·11	−9·12	1	−8·30
5½	−9·12	−9·12	360	−8·50
6	−8·95	−8·94	359	−8·56
6½	−8·52	−8·54	358	−8·54
7	−8·00	−7·95	357	−8·30
7½	−7·09	−7·08	356	−7·91
8	−6·11	−6·12	355	−7·26
8½	−4·80	−4·80	354	−6·62
9	−3·53	−3·48	353	−5·86
9½	−1·94	−1·96	352	−4·93
10	−0·60	−0·60	351	−3·85
10½	+1·12	—	350	−2·67
—	—	—	349	−1·60
—	—	—	348	−0·32
—	—	—	347	+0·74

These results are plotted together with true sine curves in Figs. 3 and 4. The curves proved to be very nearly symmetrical, so that only one half has been given. The saturation curve connecting maximum E.M.F. and field current was taken with armature A. The results are given below, and are plotted in Fig. 5.

TABLE II.—Data of Saturation Curve. Speed 1,465.

Field current in amperes.	E.M.F. in volts.	Field current in amperes.	E.M.F. in volts.
3·40	5·56	8·06	8·10
4·12	6·16	9·38	8·52
4·93	6·74	11·12	9·23
6·10	7·40	14·40	10·10
7·08	7·70	15·00	10·18

* *Telegraphic Journal*, 1874, II., 317.

METHODS OF USING THE MACHINE.

The following methods are all based on the assumption that we have a sinusoidal E.M.F. of known period, acting in a circuit containing only true resistances and inductances. The current at any instant will be expressed by the equation

$$i = \frac{E}{\sqrt{R^2 + P^2 L^2}} \sin\left(P t - \tan^{-1}\frac{LP}{R}\right).$$

The maximum value of the sine term being unity, we have

$$\frac{I}{E} = \frac{1}{\sqrt{R^2 + P^2 L^2}},$$

I and E being the maximum current in, and maximum E.M.F. impressed upon, the part of the circuit under discussion. Also the lag between current and E.M.F. is expressed by $\tan\theta = \frac{LP}{R}$. From these two equations we have

$$L = \frac{E}{IP}\sin\theta, \quad \text{and } R = \frac{E}{I}\cos\theta.$$

Our aim is, therefore, to obtain the values of the impedance, angle of lag, and frequency, and to calculate the coefficient of self-induction and the resistance for any given periodicity by the above formulæ.

(*a*) If we make up a circuit of the movable armature, a known resistance of negligible inductance, and the unknown coil, all in series, we may, by means of the measuring arrangement already mentioned, obtain E and I, the latter by the maximum P.D. around the known resistance. The angle θ would best be found by taking measurements on both sides of the zeros of current and E.M.F., and interpolating for the zero points. The difference of readings of the micrometer so obtained divided by 20 gives the angle θ. L and R are to be calculated by the above formulæ.

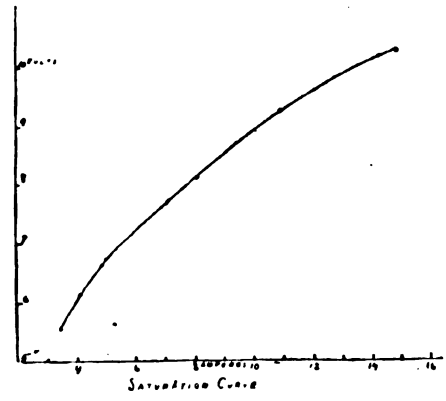

FIG. 5.

(*b*) If we have a carefully made plot, like Fig. 5, connecting the maximum E.M.F. and field current of one dynamo, we may proceed as follows. As the wave forms are alike, both following the sinusoidal law, we may apply Poggendorf's method of balancing E.M.F.'s directly, using a suitable telephone instead of a galvanometer. To do this make up a circuit of the stationary armature, known inductionless resistance, and unknown coil. Keep the field current of this dynamo constant. Attach the second armature through the telephone, first to the terminals of the known resistance. Adjust the phase relation for a minimum of sound in the telephone; then adjust for silence by varying the field current. Read the micrometer head and value of exciting current. Repeat this process at the terminals of the unknown coil. These measurements furnish the data necessary for the calculation of L and R. θ is given by difference of micrometer readings divided by 20, as before. Owing to lack of exact similarity of E.M.F. waves it would be necessary in practice to adjust by a minimum, annulling the fundamental.

(*c*) The trouble of taking the preliminary curve, as well as any uncertainty which its use may introduce, can be avoided by the connections shown in Fig. 6.

This method differs from the preceding only in the use

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of a derived E.M.F. for balancing, and in the method of its adjustment. For convenience give R_1 such a value that the P.D.'s around R_1 and R shall be about equal. Adjust the phase of armature A by the tangent screw, and adjust for amplitude by varying the field current, final adjustment being obtained by the slider.

Now change the connection to the terminals of the unknown coil, and again adjust for silence, making the adjustment for amplitude in this case by the slider alone. If the two values of the slider resistance are R_2 and R_3, then $\frac{I}{E} = \frac{R_2}{R_1 R_3}$. θ is given by the micrometer head as before.

(*d*) We may use a differential telephone—that is, a telephone having two opposed windings of equal influence and resistance, in the manner shown in Fig. 7.

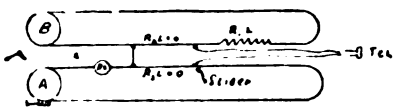

FIG. 6.

R_T is a resistance equal to that of one coil of the telephone and of negligible inductance. Adjustment is to be made until with the same value of i_A the telephone is silent when in place, as shown, and when interchange with R_T, then $R_1 = \frac{E}{I}$. θ is given by micrometer readings as before.

(*e*) We may also use the differential telephone to indicate when an unknown inductance is neutralised by a condenser of known variable capacity by placing one of its coils in series with the inductance and condenser, and the other in series with a variable inductionless resistance, R_1, shunted around the above condenser, inductance, and telephone coil, if the resistance, R_1, and capacity, C, be varied until silence is obtained. Then $L = \frac{1}{C P^2}$ and $R = R_1$. It will be desirable to employ an air-condenser to eliminate absorption effects, though this procedure has the disadvantage of requiring a very bulky and costly condenser when small inductances are to be measured.

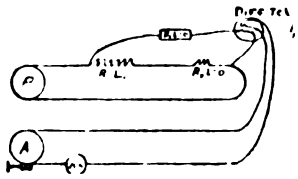

FIG. 7.

With this apparatus we may also determine the electrostatic capacity of a condenser when not complicated by absorption effects. For instance, by the first method we should insert in series with the condenser an inductionless resistance of such a magnitude that the angle of advance could be determined with accuracy.

Then $\frac{I}{E} = \frac{1}{\sqrt{R^2 + \frac{1}{C^2 P^2}}}$, $\tan \psi = \frac{1}{C R P}$,

$$C = \frac{I}{E P \sin \psi}, \text{ and } R = \frac{E}{I} \cos \psi.$$

If $R = 0$, $\psi = 90$deg, and $C = \frac{I}{E P}$.

The above are the chief uses to which the apparatus may be put.

We hope in the near future to investigate the transmission of telephonic and telegraphic signals, and to study various small induction coils such as are used in telephony, as well as the errors introduced into results by the above methods owing to lack of fulfilment of the assumed law by the E.M.F.

THE GRASSOT ELECTRICITY METER.

This type of meter is described in the current issue of *L'Industrie Electrique*. A general view of the apparatus is given in Fig. 1, and a diagrammatic sketch in Fig. 2. Our contemporary says:

"Let us suppose a silver wire, *f*, is perfectly calibrated, and that the lower point is made in the form of a cone. We will place this wire in a vertical position, the lower point resting upon a glass plate, *a*, lightly dipped in a solution of nitrate of silver, and arrange on the upper end of the wire a mass, *p*, the object of which is to depress the lower point on to the glass plate. In these circumstances, if we pass a current through a part or the whole of the wire, leading in the current through *m* by means of a spring, S, which presses upon the wire, and by making it come out by a silver electrode, *e*, after having traversed the solution of nitrate of silver, the lower part of the wire, *f*, will be worn to an extent proportional to the quantity of current which has traversed it. We shall then be able to measure the quantity of electricity that has passed through the wire by the wear of this wire.

"In order to show this wear, and to allow of its being measured, the meter is arranged in the following manner:

"The silver wire, *f*, is led into a glass tube, into the interior of which the mass, *p*, can slide. It is pressed by a multiple contact spring, S, the same that brings the current on a roller, G, of a determined diameter. In the descending movement of the wire, the roller, G, is drawn away. If, then, we arrange on the axis of this roller a needle,

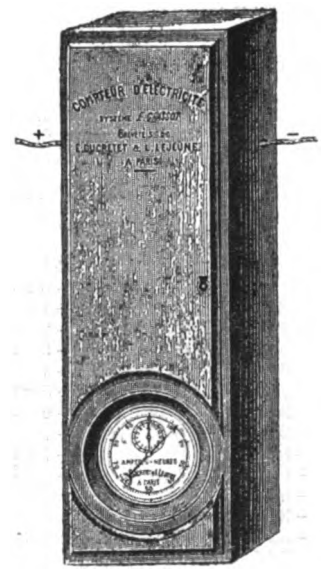

FIG. 1.

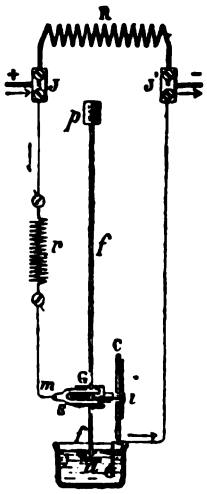

FIG. 2.

i, moving in front of a divided dial, C, we shall be able to graduate the dial in ampere-hours, and we shall thus obtain a meter of extremely simple intensity, and of assured working.

"In practice, only a determined fraction of the current is passed through the silver wire. For this purpose, there is arranged between the terminals, J and J', of the meter a weak resistance, R, and between its terminals the meter proper is placed in shunt with a great additional resistance, *r*. The resistance of the electrolytic bath being very weak, it may be said that the current is divided between the two circuits in the inverse ratio of the resistances, R and *r*; the graduation of the dial is consequently established. By this means a too rapid wear of the silver wire is avoided. The silver contained in the wire is not lost; it is found integrally upon the electrode, *e*. The apparatus is arranged in a box, which is provided with rubbing springs establishing contact with the meter.

"Let us now see the working conditions of the meter. For the meter of a maximum of three amperes $R = 0{\cdot}4$ ohm, and $r = 2{,}750$ ohms. Under these circumstances the errors are as follows:

Discharge in amperes.	Percentage of error.
·5	6
1·5	2
3	0

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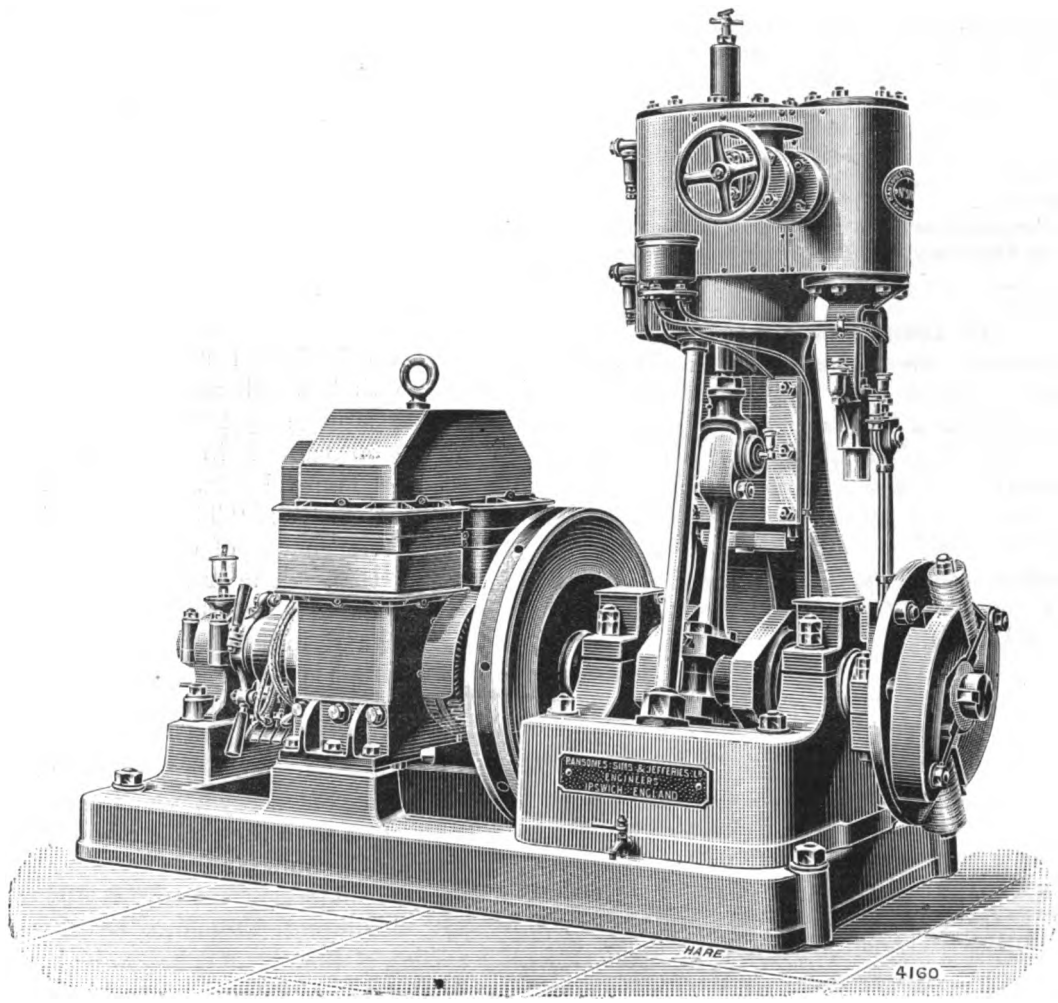
"These errors," *L'Industrie Electrique* concludes, "may be regarded as negligible in practice, and the meter may be advantageously used in installations of from one to six lamps."

COMBINED HIGH-SPEED ENGINE AND DYNAMO.

In the accompanying illustration is shown a combination which has recently been introduced by Messrs. Ransomes, Sims, and Jefferies, Limited, of Ipswich, and 9, Gracechurch-street, E.C. The engine has been designed purposely for operating dynamos, pumps, centrifugal fans, and other kinds of machinery driven at high speeds, either direct coupled or operated by belt, and it is particularly applicable for ship-lighting. The combination, as will be seen from the illustration, forms a neat and compact arrangement; the engine is double acting, the construction being that known as the "open" type. The engraving shows the general design of the engine, which can be built with the valve-chest and flywheel reversed in position if required.



A very high boiler pressure and an ample margin of safety have been allowed for in calculating the strengths and wearing surfaces of the various parts; and while such a course is not recommended, these engines may be worked direct from the boilers of triple-expansion engines without risk of breakdown or heating. The reciprocating parts are all accurately balanced. The cross-head is of cast steel, and the gudgeon is so fitted that the loosening of one nut and a slight tap will release it, and admit of the examination of the brasses. The cross-head gudgeon and the crank-pin are both of very large diameter, and the width of each of these bearings is equivalent to twice the diameter; the shaft bearings are also of exceptional size. The bearings are provided with screw adjustments, and are accessible without the slightest difficulty. The lubrication of the working parts is effected automatically, and is continuous; the cylinder is provided with a self-acting cup, and the crank-pin is fitted with a centrifugal oiler. This oiler and the cups at the top ends of the rods are supplied from a central oil-box placed in a convenient position and provided with a sight-feed arrangement to each supply pipe. A wrought iron splash-guard, which is not shown in the illustration, is provided.

The engine shown in the illustration is fitted with an automatic expansion shaft governor, which acts direct upon the piston slide-valve and varies the cut-off in proportion to the load. If preferred, a throttle-valve governor on the Pickering principle may be used instead of the shaft governor. The speed can be adjusted as may be desired while the engine is running with the Pickering governor, and a special patent attachment can be provided with the shaft governor to attain the same object. The engine has a cylinder 8½in. diameter by 8in. stroke. It is coupled to a dynamo made by Messrs. Laurence, Scott, and Co., of Norwich. The output is 180 amperes at 65 volts when running at 270 revolutions. The field magnets are constructed of special magnet steel cast in one piece. The armature is built up in the usual way with charcoal iron discs, each of which is driven in by three keys from the shaft. The conductors, which are of pure copper strip well insulated with mica, are let into slots milled in the discs. By this means an extremely strong mechanical job is made, whilst at the same time the magnetic and electrical difficulties that were at one time involved in these slotted armatures have been entirely overcome by correct proportioning of the different parts. Sparking at the commutator and the excessive lead required for the brushes have been entirely obviated by careful design, and by means of the electrical company's patent pole-pieces, the lead required up to half load being 0 and only 7½deg. for full load.

This type of engine is manufactured by Messrs. Ransomes, Sims, and Jefferies in six standard sizes. A considerable number of engines and several combined engines and dynamos have already been supplied, and are giving great satisfaction.

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THE
ELECTRICAL ENGINEER.

Published every Friday.
Price Threepence; Post Free, Threepence Halfpenny.
Editorial and Publishing Offices:
139-140, SALISBURY COURT, FLEET STREET, LONDON, E.C.

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BOUND VOLUMES.

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REFUSE DESTRUCTORS.

The idea that by using a refuse destructor sufficient waste heat can be obtained to provide for electric lighting has entered the minds of many town councillors, and will be difficult to correct. It is the interest of new destructor designers, patentees, and constructors to make everything connected therewith appear as rosy as possible. The recent issue of Mr. Jones's book on "Refuse Destructors," and Prof. Unwin's "On the Development and Transmission of Power," may provide food for consideration. Let us take Prof. Unwin's views. He estimates the refuse to be destroyed in destructors as amounting to "from one hundred tons to four hundred tons per hundred inhabitants per annum." Take the lower figure, which gives one ton per year per inhabitant. Further, it is estimated that we may get "eighty-eight effective horse-power from six cells burning a total of one and a half tons of refuse per hour. This is about forty pounds of refuse to the effective horse-power hour." With these figures as a starting point we get the destruction of thirty-six tons of refuse per day, or just over twelve thousand tons a year. At the ton per man per year rate, this means the destruction of the refuse of a town of twelve thousand inhabitants. From such destruction we should get one hundred and seventy-six effective horse-power, so that it will at once be seen that, without some storage system, this amount of energy would be altogether inadequate to supply both street and house lights. But Prof. Unwin goes further. He says: "The chief difficulty in using the available energy of destructors for power purposes is this. The refuse must be burned at a nearly regular rate. But demands for power are fluctuating and intermittent. Presently, a method of heat storage is to be described which overcomes this difficulty. The adoption of such a method would render the utilisation of the waste heat of destructors much more practicable, and would give to this source of energy a much greater importance in connection with the problem of distributing power in towns. Of course, refuse is a very poor fuel, and there is considerable expense in labour in burning it. It would not, therefore, be chosen as a fuel for raising steam. But it has to be burned for sanitary reasons. If any profit can be made by utilising the heat, that is a gain. The cost of the power obtained is merely the interest on the cost of the boilers and appliances which have to be added to the destructor, in order to utilise the heat which would otherwise be wasted."

That is a clear statement, and should never be forgotten. The first object of a destructor is a sanitary one, and it must fulfil this object at all costs. If, without detracting from its efficiency as a sanitary engine, we can utilise the waste heat for lighting purposes, so far so good. We are glad also to read Prof. Unwin's remark that "refuse is a very poor fuel," because interested parties are trying to induce town councillors to believe that refuse is as good a fuel as ordinary coal. This attempt may seem improbable to those who do not fully comprehend the wiles of inventors—

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but such is the fact, and only the other day the question was being discussed by a number of municipal engineers whose statements, if heard, might possibly have shamed some of those whose talk is tall and whose statements are not made with a rigid adherence to accuracy. Before referring to storage, it may be as well to see how far the maximum of four tons of refuse per inhabitant per year would go to provide light. Taking forty pounds of refuse as giving an effective horse-power hour, four tons would give two hundred and twenty-four horse-power hours, and this spread over three hundred and sixty-five days would give less than three-quarter horse-power hour per day per head of population. Under these, the best conditions with an average household of five persons, we should get three and three-quarter horse-power hours per day per house, which, under the doctrine of averages, might be deemed sufficient to provide light. We think, however, when the total population is considered, that the average refuse would be much nearer the minimum adopted above than the maximum. All agree upon one point, and that is, where destructors are used there must be a considerable amount of waste heat. This arises from the fact that the escaping gases must be at a high temperature. How much heat and how may it be effectually used is the problem for consideration. Properly fired, the waste heat should be far more constant than the demand for lighting or power purposes would require; hence, if this constant product could be effectively and economically stored, municipal authorities might at any rate obtain a fair start for their lighting work. We consider that it is the duty of the authorities to provide all artificial light, but if their efforts are restricted to street-lighting, it is pretty safe to say that, with the waste heat from destructors at command, they could provide all required. Taking the town of twelve thousand inhabitants as supplying refuse for an effective output of one hundred and seventy-six horse-power. This multiplied by twenty-four gives over four thousand horse-power hours, and if stored for sixteen hours out of the twenty-four, with a loss of 25 per cent. would give about three thousand five hundred horse-power hours. Prof. Unwin treats two methods of storing, one by storage batteries, which he concludes is not so good as the thermal storage suggested by Mr. Druitt Halpin. We are not altogether in accord with Prof. Unwin in his conclusions on the storage problem, but it suffices now if we once more call attention to the possibilities of utilising the waste heat of destructors for lighting purposes, without admitting that even the most economical or most effective will give the whole or any particular proportion of the light required.

ROYAL SOCIETY CONVERSAZIONE.

On Wednesday evening the second or Ladies' Conversazione was held in the rooms of the Royal Society, Burlington House, when a large company was received by Lord Kelvin (president) and Lady Kelvin. Prof. Worthington and Mr. Cole, in a series of striking photographs, reproduced and extended the old experiment of Mr. Campbell, of Islay, who printed the splash of a drop from a wood block on which ink had fallen. The new experimenters employed mercury falling on a sensitive plate illuminated at the instant of impact by the spark from a Leyden jar. They also, by an adaptation of lenses, photographed the splash by reflected light. In physiological optics, Mr. Shelford Bidwell showed a new experiment, which proved one of the most attractive features of the evening. A rapidly-moving spot of green light on a dark screen was shown to be dogged at the distance of five seconds of time by a violet-tinted "ghost" When the speed of the green spot is increased, the "ghost" moves further back on the screen, and when it is reduced the violet spot approaches and coalesces with its primary. A striking novelty in the practical application of electricity was shown by Mr. T. Snedekor. It is a light quilt, which may be of any size, the interior being occupied by resistances which generate heat when a current passes, and so keep up a uniformly high temperature in the fabric for any time. Wrapped in such a sheet, one may have the effects of a Turkish bath without any special structure, and on a smaller scale the contrivance takes the place of hot poultices and fomentations. It is devised specially for hospital use. The Postmaster-General showed the Wheatstone automatic telegraphic transmitter, driven by Willmot's air motor. The air motor in this instrument dispenses with the 42lb. weight which, when the instrument is running at 600 words per minute, requires rewinding by the operator every few seconds. He also exhibited Prof. Hughes's type-printing receiving instrument, driven by Willmot's air motor, which here takes the place of the 132lb. weight previously used, and dispenses with the whole of the winding gear and nearly all the train of wheelwork, the motor being applied directly to the printing shaft. He also showed a less scientific though much more popular piece of Post Office work in the shape of a collection of curiously-addressed letters and Christmas cards. An electrical application to the transmission of writing was shown by Prof. Elisha Gray in his telautograph, by which a writer at one station, using a lead pencil attached mechanically to the apparatus, and writing upon ordinary paper, transmits to the distant station a facsimile of his handwriting at his ordinary writing speed. Sketches, sketch-portraits, diagrams, plans, trade-marks and the like, as well as the characters of hieroglyphic alphabets, may also be transmitted. Mr. J. W. Swan has produced a continuous gold-leaf by electrical deposition; the glass plates coated with it flash like yellow mirrors in reflected light, but transmit a greenish light when looked through, illustrating the perfect transparency of thin gold. In pure electricity, Prof. Oliver Lodge brought forward a compact and portable instrument for detecting electrical radiation, and a spherical radiator of short Hertz waves, with which he performed a number of experiments; and Sir David Salomons showed two new contact makers and breakers. Prof. Silvanus Thompson repeated his entertaining experiments with rotating magnetic fields, and drew crowds to see Prof. Hughes's induction balance adjusted for testing the existence of metallic plates in bullet-proof shields.—*The Times.*

THE WATERHOUSE ELECTRICITY METER.

We had last week an opportunity of inspecting a new form of electricity meter devised by Mr. Addison G. Waterhouse, an electrician whose inventions in the shape of arc lamps, etc., have for some time past achieved a measure of fame in the United States.

The appliance now under notice belongs to the class of electrolytic meters; it consists essentially of an arrangement for measuring and registering the volume of gas produced by a small fraction of the current used by the consumer. The gas is formed and measured in a glass collecting bell of somewhat novel shape, being provided with an inverted syphon tube, which discharges the gas as soon as a certain volume has been collected, and at the same time moves a registering mechanism to indicate the

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number of times the collector has been filled. Fig. 1 shows the electrolytic cell, C, and the collector, B, with the inverted syphon tube, T, both being partly filled with a volume of gas, G. After the gas has accumulated until it forces the fluid down to the bend in the tube at *u*, it will start up the tube at *v*, and bubble out, leaving the bell full of fluid and ready to collect another charge of gas. At W is represented an indicating arrangement which is worked by the rise and fall of the collector, B, according as the gas collects or escapes; the vertical motion of B is thus made by means of pointers and dials to indicate the number of times B has been filled with gas.

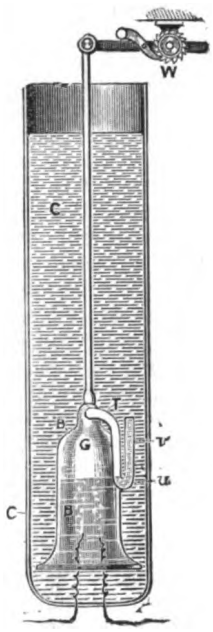

FIG. 1.

In the practical construction of such a meter, there are, says the inventor, certain difficulties to be overcome inherent to electrolytic meters in general. These are: the changes of resistance resulting from variations in temperature and specific density of the liquid used as an electrolyte; the counter E.M.F. offered by an electrolytic cell to the passage of a current through it, which in this case is about two volts, platinum electrodes in dilute sulphuric acid being used. "To meet these difficulties, we use the pressure of a derived circuit current, which, in turn, varying with the voltage on the main circuit, produces deranging effects; these, again, we overcome even to the extent that a change of 50 per cent. of voltage will not change the effect of this derived circuit, in its effect, as applied to the meter."

To explain the electrical action of this meter, reference may be made to the accompanying drawings.

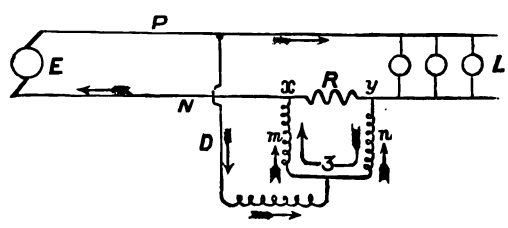

FIG. 2.

In Fig. 2, E represents the dynamo or other source of energy, and L the lamps; R is a small resistance in the main line, N, and P is the positive wire to the lamps, the difference of potential between P and N being 100 volts. A derived or shunt circuit, D, connects the mains, dividing between *m* and *n*, each branch joining wire N at the extremes of the resistance, R, or at *x* and *y*. If no current is passing to the lamps, L, none is returning through the resistance, R, and therefore there is no fall of potential between *x* and *y*; the result is that the derived circuit current starting from P to 3, and then dividing between *m* and *n* in an inverse proportion to their resistance, will mostly pass to wire N on branch *n*, as its resistance is comparatively low, and a very small part on branch *m*, as its resistance is comparatively high, and the direction of these branch currents will be as indicated by the short arrows. If a current starts to the lamps, L, and returns through R on line N, there will be a fall of potential between the extremes of R, or between *x* and *y*, which will correspond to the amount of current passing from the lamps, so as this current passes through R some of it will tend to pass around the shunt formed by *n* and *m* in the direction of the long bent arrow. This current will oppose the derived circuit current from 3 up through *n*, and compel more of it to pass up through *m*; and thus the current through *m* will increase with the change of potential between *x* and *y* due to the volume of current returning

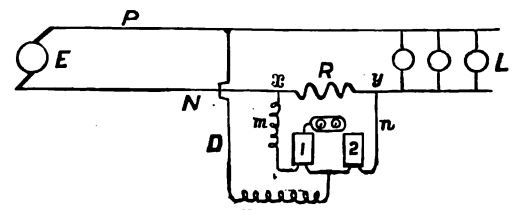

FIG. 3.

from the lamps. In order to measure the change of current in *m*, an electrolytic cell is inserted, with an arrangement, as shown, for measuring the current by the volume of gas which it evolves.

To prevent any effect due to changes of resistance caused by heat or changes in the specific density of the liquid, a similar cell, but without any measuring device, is placed in branch *n* (see Fig. 3), so that they will both be under the same conditions and mutually counteract for each other the effect of any disturbing changes. Further, in order to overcome the counter E.M.F. offered by these cells, a pressure of 100 volts is maintained through the derived circuit, D, and the changes of potential between *x* and *y* due to the main current will shift more or less current from path *n* to path *m*, being then measured and registered as shown.

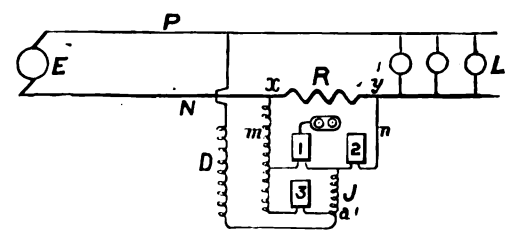

FIG. 4.

As the difference of potential between *x* and *y* is limited to ·5 volt, and the counter E.M.F. offered by cells 1 and 2 is over 4 volts, it is evident that none of the current passing through R will pass round the shunt formed by resistance *m*, cells 1 and 2, and conductor *n*; but the difference of potential between *x* and *y* caused by the current in R will cause a corresponding proportion of current to flow through cell 1 (in which it is measured by means of the gas evolved), as would otherwise flow through cell 2. The current which passes through R is measured indirectly by measuring that part of the shunt current which comes through D, and divides, so that a part will pass through the measuring cell 1 (which will correspond to the current in R). It is, therefore, plain that a constant quantity of current must flow through the derived circuit, which in common use would not be constant, owing to the changes of voltage between the main lines, P and N, and to remedy this defect use is made of a third cell, as shown in Fig 4.

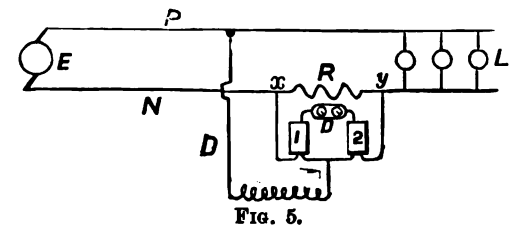

FIG. 5.

In this case cell 3 is placed as a shunt around cell 1 and the resistance, J: a complete meter is thus arranged, and if adjusted to 100 volts the derived circuit current will

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divide between the cells 1, 2, and 3, and the proportion going through the measuring cell 1 will vary with the main current passing through R. Then if the voltage varies and causes more or less current to pass through the derived circuit, cell 3 will take more or less current so as to keep the amount of current which divides between cells 1 and 2 constant.

Another way of constructing this meter is shown in Fig. 5, where the floats in cells 1 and 2 mark the indicator, D, in opposite directions, so that when a very small current is passing through R the action of cell 2 will nearly counteract that of cell 1, but when the current increases in R, it will increase in cell 1 and diminish in cell 2, and the indicator, D, will show the difference due to the current in R.

This form of meter, as shown in Fig. 5, has several very important advantages over any other form, and these will probably cause it to be the type adopted. By reason of its differential action, extreme sensitiveness is attained, enabling it to take a wide margin of measurements, as it will record the current used from a small fraction of one lamp to almost any desired number; and as it contains no resistances or parts that require careful measurements, it is easy to calibrate. Changes in the voltage, it is claimed, do not materially affect this meter, owing to the fact that, as it works differentially, any change in the derived current will balance itself on both sides when no lamps are burning; and when lamps are put on, any change of current in the derived circuit, if increased, will reduce the changing-over effect of the main circuit current, on account of the increased difference of potential between the extremes of the paths through the meter, and in case of a fall of voltage opposite effects will compensate for the difference.

A special device is used in this meter (though not shown) which stops the shunt circuit current when all the lamps are turned out, and starts it as soon as one lamp is turned on.

In refilling the cells used in this meter, nothing but pure water is added after the first filling, this being repeated about once every three months.

The completed meter is contained in an oblong metal case standing 12½in. high, with index in the front reading as with a gas-meter. Three terminals are provided—two for the mains and a third for the shunt.

UNIPOLAR DYNAMOS FOR ELECTRIC LIGHT AND POWER.

A paper dealing with the above subject, by Messrs. F. B. Crocker and C. H. Parmly, was presented to the American Institute of Electrical Engineers at the recently held eleventh annual meeting. The object of the authors was to show that unipolar dynamos and motors are much more practical and generally applicable than is ordinarily supposed to be the case. The name "unipolar" was pronounced unsatisfactory, aud "continuous pole" was suggested as a good name for this type of generator. It was pointed out that iron or steel is much better than copper for the armature on account of its strength, whilst its resistance is no objection on account of the great mass of metal used. The authors described a type of unipolar machine, and adduced formula for its design. It was shown that the armature of a machine of this type for 10 volts at 1,200 revolutions need be only 24·28in. in diameter, and for 130 volts and 200 revolutions 214·4in. The capacity of the latter machine was shown by the statement that if two were coupled to the shaft of a 100,000-h.p. engine, they would develop more current than at present is consumed in any two cities of the world, and if run even as low as 1,000 h.p. the loss in the armature would only be 4 or 5 per cent. The great advantage of the unipolar machine in extreme simplicity was indicated. Its armature consists of nothing but a solid cylinder or disc of steel or other suitable metal firmly mounted upon a shaft, whilst the construction of the field magnet and the rest of the machine is also very simple. There should be, according to accepted theories, no hysteresis in these machines, no Foucault currents, and probably no armature reaction. In conclusion, the authors stated that unipolar machines are practically indestructible, since they are so simple and so strong that they are not likely to be damaged mechanically, and that it is almost impossible to conceive of one being burnt out or otherwise injured electrically, since the engine would be stalled by the enormous current before the armature could be fused by it. A machine possessing all these important advantages, they observed, certainly deserves a prominent place in electrical engineering, whereas it now has practically no existence.

A BURGLAR ALARM.

The majority of burglar alarms will be found, it is to be feared, by no means brilliantly successful in achieving the purpose for which they are designed; in fact, they are said somewhat facetiously to be handy little things for the enterprising housebreaker to pick up and put in his pocket. One will always fetch a shilling or two for use as an ordinary electric bell. Perhaps this want of success may follow from the proneness of householders to relax their efforts, allow alarms to get out of order and remain so. Indeed, there is a strong temptation at the present time to take out a burglar insurance policy and let the midnight marauders work their own sweet will. Still, there ought to be an extensive opening for electrical appliances of the kind, whether in business or private premises. If a watchman's tell-tale is worth adopting, there seems no reason why a somewhat similar appliance should not find useful service in helping the watchman. Messrs. Siemens Bros. and Co., Limited, have patented and are bringing on the market a type of burglar alarm, the special object of which is to arrange the usual contact appliance in such a position as to render it invisible and not readily accessible, besides being protected from dust and damp. This end is attained by fixing the magnet which actuates the alarm by closing or opening a circuit within the door jamb or window frame, whilst the contact lever is similarly embedded or sunk in the door frame itself, or *vice versâ*. On opening the door or window the influence of the magnet is withdrawn, and a spring or weight throws over the contact lever and completes the circuit. There does not seem any great striking novelty in this contrivance, but it doubtless offers some little improvement over those hitherto seen on the market, if only for the points mentioned.

PRACTICAL NOTES ON DYNAMO CALCULATION.—II.

BY ALFRED E. WIENER.†

(Continued from page 641.)

4. *Field Density.*—The specific strength of the magnetic field has to be chosen according to the size of the machine, the number of poles, the form of the armature, and to the material of the pole-pieces. In general, the higher a density of the magnetic lines per unit of field area is taken, the larger the output of the dynamo, and in multipolar machines greater values of $\mathfrak{B}$ are admitted than in bipolar ones. In dynamos with smooth-core armatures the field densities are greater than in those with toothed armature bodies, for in the latter a portion of the lines enters the teeth and passes through the armature without cutting the conductors; for such armatures it therefore takes more lines per square inch of pole area to produce the same field density (per square inch of area occupied by armature conductors) than for smooth cores, and consequently smaller field densities are to be taken in order to prevent over-saturation of the pole-pieces, and, eventually, of the frame. This leakage through the

* In the first section of this serial, on page 641, the symbol F has been used to denote the field density; hereafter, the symbol $\mathfrak{B}$ will be employed for the field intensity, in accordance with the congress notation of 1893. All who intend to follow this treatise are advised to make the substitutions indicating this change of notation, as reference will be made to formula (1) in future sections.

† The *Electrical World.*

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armature takes place in the higher degree the greater the width of the teeth compared to that of the slots, and therefore still smaller field densities are to be chosen in case of armature cores with tangentially projecting teeth, and of those with closed slots. Finally, in machines having wrought-iron or steel pole-pieces, the densities can be taken about 50 per cent. higher than in those with cast-iron pole shoes.

TABLE IV.—Practical Field Densities in English Measure.

Field Densities, in Lines of Force per square Centimeter

Capacity in Kilo Watts	Bipolar Dynamos						Multipolar Dynamos					
	Smooth Armature Core		Toothed Armature Core				Smooth Armature Core		Toothed Armature Core			
			Straight Teeth		Projecting Teeth				Straight Teeth		Projecting Teeth	
	Cast Iron Polepieces	Wr't Iron or Steel Polepieces	Cast Iron Polepieces	Wr't Iron or Steel Polepieces	Cast Iron Polepieces	Wr't Iron or Steel Polepieces	Cast Iron Polepieces	Wr't Iron or Steel Polepieces	Cast Iron Polepieces	Wr't Iron or Steel Polepieces	Cast Iron Polepieces	Wr't Iron or Steel Polepieces
·1	1550	2300	1250	1850	—	—	2150	3100	1850	2800	—	—
.25	1850	2800	1550	2300	—	—	2500	3700	2150	3250	—	—
.5	2150	3100	1850	2800	—	—	2800	4200	2500	3700	—	—
1	2300	3400	2000	2950	1250	1850	2950	4350	2650	3850	1550	2300
2·5	2500	3700	2150	3100	1400	2150	3100	4500	2800	4000	1700	2500
5	2650	3850	2300	3400	1550	2300	3250	4700	2950	4350	1850	2800
7·5	2800	4000	2500	3700	1700	2500	3400	5000	3100	4700	2000	3100
10	2950	4350	2650	3850	1850	2800	3700	5400	3250	5000	2150	3300
25	3100	4700	2800	4200	2000	3100	4000	5900	3400	5400	2300	3500
50	3400	5100	3100	4700	2150	3400	4350	6400	3550	5900	2500	3700
100	3700	5600	3400	5100	2500	3700	4700	6800	3850	6300	2650	3850
200	4200	6400	3700	5600	2800	4200	5000	7300	4200	6500	2800	4000
300	4700	7000	4200	6200	3100	4700	5400	7750	4500	6800	2950	4350
500	—	—	—	—	—	—	5900	8200	4800	7200	3100	4700
1000	—	—	—	—	—	—	6400	8700	5100	7500	3400	5000
2000	—	—	—	—	—	—	7000	9300	5400	7800	3700	5400

TABLE V.—Practical Field Densities in Metric Measure.

Field Densities, in Lines of Force per square inch

Capacity in Kilo Watts	Bipolar Dynamos						Multipolar Dynamos					
	Smooth Armature Core		Toothed Armature Core				Smooth Armature Core		Toothed Armature Core			
			Straight Teeth		Projecting Teeth				Straight Teeth		Projecting Teeth	
	Cast Iron Polepieces	Wr't Iron or Steel Polepieces	Cast Iron Polepieces	Wr't Iron or Steel Polepieces	Cast Iron Polepieces	Wr't Iron or Steel Polepieces	Cast Iron Polepieces	Wr't Iron or Steel Polepieces	Cast Iron Polepieces	Wr't Iron or Steel Polepieces	Cast Iron Polepieces	Wr't Iron or Steel Polepieces
.1	10000	15000	8000	12000	—	—	14000	20000	12000	18000	—	—
.25	12000	18000	10000	15000	—	—	16000	24000	14000	21000	—	—
.5	14000	20000	12000	18000	—	—	18000	27000	16000	24000	—	—
1	15000	22000	13000	19000	8000	12000	19000	28000	17000	25000	10000	15000
2.5	16000	24000	14000	20000	9000	14000	20000	29000	18000	26000	11000	16000
5	17000	25000	15000	22000	10000	15000	21000	30000	19000	28000	12000	18000
7.5	18000	26000	16000	24000	11000	16000	22000	32000	20000	30000	13000	20000
10	19000	28000	17000	25000	12000	18000	24000	35000	21000	32000	14000	21000
25	20000	30000	18000	27000	13000	20000	26000	38000	22000	35000	15000	22000
50	22000	33000	20000	30000	14000	22000	28000	41000	23000	38000	16000	24000
100	24000	36000	22000	33000	16000	24000	30000	44000	25000	40000	17000	25000
200	27000	40000	24000	36000	18000	27000	32000	47000	27000	42000	18000	26000
300	30000	45000	27000	40000	20000	30000	35000	50000	29000	44000	19000	28000
500	—	—	—	—	—	—	38000	53000	31000	46000	20000	30000
1000	—	—	—	—	—	—	41000	56000	33000	48000	22000	32000
2000	—	—	—	—	—	—	45000	60000	35000	50000	24000	35000

The suitable values of $\mathfrak{B}$ for all these various cases are tabulated in Table IV., which gives the average densities in lines of force per square inch, while Table V. contains the corresponding values of $\mathfrak{B}$ in lines per square centimetre.

For very low-potential machines (electroplating dynamos, battery motors, etc.), about 3-4 of the densities given in Tables IV. and V. are to be taken.

5. *Length of Active Armature Conductor.*—By means of the specific armature induction obtained from formula (1), the total length of active wire to be wound upon the pole-facing surface of any armature can be readily determined. If E denotes the total E.M.F. generated in an armature, and L_a the total length of active wire wound on it, then E divided by L_a will give the specific armature induction, V. The length of active conductor for any armature can therefore be obtained from the formula

$$L_a = \frac{E}{V}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

in which

L_a = total length of active conductor (on whole circumference opposite pole-pieces), in feet;

E = total E.M.F. to be generated in armature—*i.e.*, volt output + additional volts to be allowed for internal resistances (see Table VI.); and

V = specific induction of active armature wire, calculated by formula (1).

Introducing the value of V from (1) into (2), the formula for the length of active armature conductor becomes:

$$L_a = \frac{E}{\frac{v}{P} \times S \times \frac{\mathfrak{B}}{20{,}000}} = \frac{20{,}000 \times P \times E}{v \times S \times \mathfrak{B}} \quad (3)$$

To find the total E.M.F., E, to be generated by the armature, increase the E.M.F., *e*, wanted in the external circuit by the percentages given in Table VI. The figures in the second column of this table refer to shunt-wound dynamos, and, therefore, take into account the armature resistance only. The percentages in the third and fourth columns are to be used for series and for compound-wound dynamos respectively, and, consequently, include allowances for armature resistance as well as for series field resistance.

TABLE VI.—E.M.F. Allowed for Internal Resistances.

Capacity in kilowatts.	Additional E.M.F. in per cent. of output E.M.F. Shunt dynamos. Per cent.	Series dynamos. Per cent.	Compound dynamos. Per cent.
Up to ·5	20 to 12	40 to 25	30 to 20
,, 1	12 ,, 10	25 ,, 20	20 ,, 15
,, 2·5	10 ,, 8	20 ,, 16	15 ,, 12
,, 5	8 ,, 7	16 ,, 14	12 ,, 10
,, 10	7 ,, 6	14 ,, 12	10 ,, 8
,, 25	6 ,, 5	12 ,, 10	8 ,, 7
,, 50	5 ,, 4	10 ,, 8	7 ,, 6
,, 100	4 ,, 3½	8 ,, 6	6 ,, 5
,, 200	3½ ,, 3	6 ,, 5	5 ,, 4
,, 500	3 ,, 2½	5 ,, 4	4 ,, 3
,, 1,000	2½ ,, 2	4 ,, 3	3 ,, 2½
,, 2,000	2 ,, 1½	3 ,, 2½	2½ ,, 2

6. *Size of Armature Conductor.*—The sectional area of the armature conductor is determined by the strength of the current it has to carry. For general work, the current densities usually taken vary between 400 and 800 circular mils per ampere; in special cases, however, a conductor area may be provided at the rate of as low as 200 to 400 mils per ampere, or as high as 800 to 1,200 circular mils per ampere. The low rate refers to machines which only are to run for a short while at the time, as, for instance, motors to drive special machinery (private elevators, pumps, sewing-machines, dental drills, etc.), while the high rate is to be employed for dynamos which have a 15 or 20 hours' daily duty, as in the case for central station, power-house, and marine generators, etc.

Taking 600 circular mils per ampere as the average current density (= 475 square mils, or ·000475 square inch per ampere, or about 2,100 amperes per square inch), the sectional area of the armature conductor, in circular mils, is to be

$$\delta_a{}^2 = 600 \times \frac{C}{2P} = \frac{300 \times C}{P} \quad . \quad . \quad . \quad (4)$$

where $\delta_a{}^2$ = sectional area of armature conductor in circular mils;

δ_a = diameter of armature wire, in mils;

C = total current generated in armature in amperes; and

P = number of pairs of magnet poles.

The size of conductor may be taken from the wire-gauge tables by selecting a wire, the sectional area of one or more of which makes up, as nearly as possible, the cross-section obtained by formula (4).

In this formula, as in equation (1), half the number of parallel armature circuits is to be substituted for P, in case the former figure should differ from the latter.

The total armature current, C, in shunt and compound dynamos is the sum of the current output, *c*, and the exciting current of the shunt circuit. The latter quantity, however, generally is very small compared to the former, and in all practical cases, consequently, it will be sufficient to use the given *c* instead of the unknown C for the calculation of the conductor area. A supplementary allowance may then be made by correspondingly rounding off the figures obtained by (4), or by selecting the wires of such a gauge that the actual conductor area is somewhat in excess of the calculated amount.

7. *Diameter of Armature Core.*—If the speed of the dynamo is given, the proper conductor velocity, taken from Table III., will at once determine the diameter of the armature. Let N denote this known speed in revolutions per minute, and d'_a the mean diameter of the armature winding, in inches; then the cutting speed, in feet, per second is

$$S = \frac{d'_a \times \pi}{12} \times \frac{N}{60}. \quad . \quad . \quad . \quad . \quad (5)$$

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from which follows:

$$d'_a = \frac{12 \times 60}{\pi} \times \frac{S}{N} \times 230 = \frac{S}{N} \quad . \quad . \quad (6)$$

From this mean winding armature, d'_a, then, the diameter of the armature core, d_a, is found by making allowance for the height of the armature winding. For small armatures—under 2ft. in diameter—the coefficients given in Table VII. may be used for this purpose; for larger ones it is sufficient to simply round off the result of formula (6) to the next lower round figure.

TABLE VII.—Ratio between Diameter of Body and Mean Winding Diameter for Small Armatures.

Size of armature.	Diameter of armature core. Drum armatures.	Ring armatures.
Up to 3in. diameter	$d_a = .88 \times d'_a$	—
,, 6in. ,,	$= .92 \times d'_a$	$d_a = .94 \times d'_a$
,, 12in. ,,	$= .95 \times d'_a$	$= .96 \times d'_a$
,, 18in. ,,	$= .96 \times d'_a$	$= .97 \times d'_a$
,, 24in. ,,	$= .97 \times d'_a$	$= .98 \times d'_a$

For dynamos with internal poles, the reciprocals of these coefficients are to be taken, or the result is to be rounded off to the next higher round figure respectively; and the dimension thus obtained is the internal diameter of the armature core. In the case of machines with internal as well as external poles, the mean winding diameter, d'_a, is identical with the mean diameter of the armature body.

If the speed of the dynamo is not given, the following Tables VIII., IX., and X. will be found useful. Table VIII. gives practical data for speeds, conductor velocities, and corresponding diameters of drum armatures. Table IX. contains similar information relating to high-speed ring armatures, and in Table X. the data for slow-speed ring armatures are compiled.

TABLE VIII.—Speeds and Diameters of Drum Armatures.

Capacity in kilowatts.	Speed, in revolutions per minute, N.	Conductor velocity in feet per second, S.	Body diameter in inches, d_a.
.1	3,000	25	1¾
.25	2,700	30	2¼
.5	2,400	32	2¾
1	2,200	34	3¼
2	2,000	36	3¾
3	1,900	40	4¼
5	1,800	45	5¼
10	1,700	50	6
15	1,600	50	6¾
20	1,500	50	7½
25	1,350	50	8¼
30	1,200	50	9
50	1,050	50	10¼
75	900	50	12½
100	750	50	15
150	600	50	18½
200	500	50	22½
300	400	50	28

TABLE IX.—Speeds and Diameters of High-Speed Ring Armatures.

.1	2,600	50	4
.25	2,400	55	5
.5	2,200	60	6
1	2,000	65	7
2.5	1,700	70	9
5	1,500	75	11
10	1,250	80	14
25	1,000	80	18
50	800	85	24
100	600	85	32
200	500	88	40
300	450	90	46
400	400	92	52
600	350	95	62
800	300	95	72
1,000	250	95	87
1,500	225	100	102
2,000	200	100	115

TABLE X.—Speeds and Diameters of Slow-Speed Ring Armatures.

2.5	400	25	14
5	350	26	17
10	300	28	21
25	250	30	27
50	200	32	36
100	175	35	46
200	150	40	60
300	125	42	78
400	100	44	100
600	90	45	115
800	80	45	129
1,000	75	45	138
1,500	70	45	148
2,000	65	45	158

(To be continued.)

SOME REMARKS ON POWER DISTRIBUTION BY ELECTRICITY, WATER, AND GAS.*

BY ED. C. DE SEGUNDO.

(Concluded from page 669.)

As the thermal efficiency of steam-engines, under such working conditions as obtained in central power-producing stations, is extremely difficult to determine with any accuracy, it may be of interest to arrive at their figure by calculation of other efficiencies as nearly as they can be estimated. Probably 9lb. of coal of calorific value of 14,500 thermal units per pound is not an excessive figure to assume as the average performance of London central electric stations per kilowatt-hour, paid for by the consumer. Now, one kilowatt-hour is equal to about 3,420 thermal units. Adding 11 per cent. for loss in distribution and allowing 1·25 as the counter efficiency of the dynamos, there should appear on the crankshaft of the engine, so to speak, the equivalent of about 4,750 thermal units. But to effect this 9lb. of coal have been burnt, liberating $145·00 \times 9 = 130,500$ thermal units, so that the efficiency or non-efficiency of working of boiler and engine, together with attendant stand-by and radiation losses, are responsible for 96·2 of the heat energy of the coal consumed. Of course, the engine and boiler, as heat machines, are not to be held accountable for the whole of this loss. It is mainly due to the conditions of working. But the question that naturally suggests itself under these circumstances is, is there no other and more efficient manner of generating and distributing light and power on an intermitting demand than by steam power, generating electrical energy and distributing it by means of copper mains?

It must not be forgotten that the coal consumption is by no means the only factor to be considered. Rents, rates and taxes, maintenances and distribution expenses, depreciation, management expenses, and a host of other items have to be tacked on to the cost of coal consumed before the figure is reached from which profits can be calculated. But even on this basis the total for power delivered is strikingly smaller in the case of hydraulic power supply than in that of electric supply. In a recent paper read before the Institution of Civil Engineers by Mr. E. B. Ellington, it was stated that the total cost per 1,000 gallons delivered at 700lb. per square inch was 12s. 6d. Now, 1,000 gallons at 700lb. per square inch is equivalent to 8·34 horse-power hours, or 6·25 kilowatt-hours nearly. There is no electric supply company in London who deliver one kilowatt-hour at a less total cost than from 3·5d. to 4½d. to themselves. Thus the cost per equivalent of one kilowatt-hour is rather more than double in the case of electric supply than in the case of hydraulic supply. The question is, as to whether this economy can be ascribed wholly to the superior economy of the steam-engine in all hydraulic power stations, having regard to the fact that not only is the hydraulic load curve similar in form to the electric load curve, but the load-factors in both cases are similar. The author thinks not entirely, as a certain proportion of this economy must be due to the difference in the inevitable losses in the system of distribution, and also to the difference in capital outlay for large powers. In comparing distribution of power by high-pressure water and by electricity, due consideration must be had to the purposes to which power is to be put. For working lifts, or cranes, or presses, it is doubtful whether any simpler and better means could be provided in a city like London than water pressure. If, on the other hand, the form in which the power is delivered has to be changed before it can be applied, it is quite possible that the efficiency of transformation may be so low as to dissipate the economy attained in generation and distribution. Compare, for instance, the number of transformations necessary to enable a lift to be worked and an incandescent lamp to be lighted from a central power-house.

Lift.

Efficiency, per cent.	Hydraulic power.	Efficiency, per cent.	Electric power.
70	Boilers	70	Boilers
13	Compound condensing engines	9	Non-condensing engines
80	Pumps (including mechanical efficiency of engine)	80	Dynamos (including mechanical efficiency of engine)
99	Distributing system	88	Distributing system
		80	Motor

Of the 14,500 thermal units liberated by 1lb. of coal, 1,044 thermal units would reappear as useful work on the hydraulic system, and 478·5 thermal units on the electric system.

Electric Lighting.

70	Boilers	70	Boilers
13	Compound condensing engines	9	Non-condensing engines
80	Pumps	80	Dynamos
99	Distributing system	82	Distributing system
66	Motor		
90	Dynamos		

On the hydraulic system about 620 thermal units should reappear in useful work and on the electric system about 600 thermal units.

The foregoing assumptions are not made with regard to any

* Paper read before the Society of Engineers.

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particular load-factor, but as the load-factor is found to be very similar in public electric supply stations and public hydraulic supply stations, the conclusions indicated by the figures should not be materially altered. There is, of course, nothing very new about this result, but it is sufficiently striking to have induced a Belgian engineer of considerable reputation to devote a large amount of time to the development of a system of hydraulic distribution in generating electrical energy which should enable electrical energy to be sold at considerably cheaper rates than at present. It is unnecessary to discuss M. Van Rysselbergh's scheme in detail. It is evident that the only directions in which the efficiency of a system as a whole can be increased are (1) by decreasing the number of transformations of energy, and (2) by increasing the efficiency of either or all of these. Now the number of transformations of energy is not decreased, but increased, in the hydraulic system. The efficiency of boilers and dynamos cannot be very different in both systems. The difference in the cost of the distributing system is conditioned by circumstances. There remain, then, two efficiencies to be improved on—the efficiency of the engine and the efficiency of the distributing system. The economy effected by a triple-expansion condensing engine, working as it does in an hydraulic power station at full load per stroke, over the steam-engines forming part of the "steam dynamos," now much used in electric generating stations, might well reach 50 per cent.—that is to say, where the steam-engine of the steam dynamo gives 10 per cent., the triple compound as above might yield 15 per cent. The loss in a mile of hydraulic main, say, 6·5in. diameter, when transmitting 100 h.p. at 700lb. per square inch at a velocity not exceeding 3ft. per second, would not greatly exceed 1 per cent., whereas the average loss in an electric distributing system rarely is less than 12 per cent., though doubtless this could be improved upon. Against these sources of economy must be placed the loss in the water motor, the loss in the extra transformation of motive power into electric light, and the loss in the low-tension network surrounding each distributing station. Further, hydraulic mains have to be placed at a considerably lower level than the electric conduits need be for many reasons, and it can scarcely be even a matter of doubt that the total commercial efficiency of the whole hydro-electric system—by which is meant the useful efficiency modified by all such considerations as rents, rates and taxes, maintenance, and depreciation, etc.—will compare unfavourably with the total commercial efficiency of direct electric supply. There can be no doubt, however, that power can be produced and delivered hydraulically at a smaller cost than the electrical equivalent electrically. There must be a reason for this, and the reason is not far to seek. In the hydraulic power station a more efficient engine can generally be used; then this engine can be worked more efficiently owing to the fact that although the engine may vary in speed, it works always at full load to the stroke. There can be, further, a much greater efficiency in distribution through pipes. In hydraulic-power supply the pressure is not a function of the speed of the pump (as in direct electric supply it is a function of the speed of the armature), but the pressure in the mains is maintained outside of the engine and pump, which only deliver enough water at a constant pressure, to supply the demand on the main.

At first sight it seems easy to apply this principle to electric supply by the introduction of an electric accumulator or storage battery to keep up the pressure on the mains. But unfortunately the analogy between an hydraulic and an electric accumulator is not quite complete: it breaks down in one important detail—namely, that while the hydraulic accumulator reacts in the same way upon both main and pump, the electric accumulator only acts in an analogous manner towards the main. Its effect upon the dynamo or electric pump is to drive the pump unless the pump is driven sufficiently quickly. What is wanted to complete the analogy is the analogue of the non-return valve, and this so far has not been discovered. Moreover, while pressure can be exerted by a pump, whose plunger is stationary, the pressure exerted by the electrical pump or dynamo is a function of the speed of rotation of the armature. Thus, in order to supply a small demand, the steam-engine of an electric generating station has to work at about 90 per cent. of the speed required to supply the full demand. There is no reason why an electrical generating station should not be able, provided the demand is sufficiently large and varied, to so apportion its generating units as to keep each unit in work loaded to 90 per cent. of its full load, in which case the only losses in the station would be 10 per cent. stand-by in boilers, radiation, etc. In the Berlin central station, where, owing to continental habits of life, the demand is more favourably distributed over the 24 hours, such a condition is very nearly approached.

Efficiency of Gas-engines.

Now let us briefly consider how power produced by gas-engines can meet the needs for electric light for a large town provided with a complete network of gas-mains. In this case (which is practically the case of every large town in the civilised world) the electric light comes as competitor against the method of illumination which has practically only just established a firm reputation for reliability, economy, efficiency, etc. There is no doubt that the conveniences of gas for lighting and heating are apt to be overlooked because of our familiarity with them. Had we experienced the inconveniences of oil and candle lighting, I feel sure the electric light would not have made so much progress as it has done Further, the gas business is in the hands of a powerful body, powerful alike in experience and in resource. Experience of practical working in London and other large towns show that in certain districts and under certain conditions there is a sufficient demand for the electric light to make it worth while to work independently of the gas company altogether. But consider the very vast majority of country towns already supplied with gas, where it is obvious that an independent electric light company would eke out a very miserable existence, and that probably for only a short time, it would certainly seem reasonable that a combination of electric light and gas interests would solve the problem of electric supply to the inhabitants; and if this is so, then the principle ought to apply *à fortiori* to large towns. At present these interests conflict, and it is universally experienced that someone has to pay for this conflict. Let us try and examine this a little more closely. If electric light and gas interests harmonise, the first advantage that suggests itself is the ready-made central station—namely, the gasworks. It is then necessary to establish distributing stations at suitable points in the town. Each distributing station would consist of gas engines and dynamos and regulating apparatus. Each distributing station would supply its own network of mains for the needs of its own neighbourhood. These networks would have to be connected by a trunk main so that any one station could be relieved by any other in case of emergency, and during the period of light load. The details of the plant of each station and the number of stations would be dictated by local conditions, so that it is impossible to do more than state the broad principles. As there would be no boilers, no chimney-stack would be required. Probably in nine cases out of ten the basement of some house could be adapted to accommodate the necessary plant, hence a great saving would be effected in special buildings. Further, the labour required would be diminished. The cost of superintendence would probably remain the same, but might be increased. Now, as to the cost per unit delivered. There is fortunately not much difficulty in determining this, as many examples of the generation of electrical energy by gas power now exist. The author has selected the results of the weekly records of a plant at Bradford supplying 300 lamps. The total cost per kilowatt-hour delivered is almost exactly 2d., with town gas at 3s. 3d. per 1,000. But to adapt this to a distributing station 5 per cent. should be added for loss in mains, and 0·3d. per kilowatt-hour for depreciation in plant and buildings. This would bring the cost to 2·4d. Adding the very liberal allowance of 0·6d. per kilowatt-hour for management expenses, the total cost would amount to 3d. per kilowatt-hour delivered. This is a lower figure than that usually realised in practice by any purely electric supply company working under the conditions above assumed, and no doubt this aspect of public electric supply has for some reason or other not receive the attention it deserves. In order that the two systems (direct use of gas and gaso-electric) be commercially equivalent, the cost of maintenance of the plant, the interest and depreciation, and management expenses must be compensated for by the economy in gas consumed.

Now it is frequently thought that nothing can be more economical than the system of sending the gas direct to the burner. But this is far from being true. The miserably low efficiency of the gas burners is rarely appreciated. According to Prof. Tyndall, the efficiency of the gas burner is 0·317 per cent. Taking the calorific value of London gas at 620 thermal units per cubic foot, only the equivalent of 10 thermal units reappear as light out of a possible 3,100 thermal units in a 5ft. burner. When gas is utilised to produce motive power, its efficiency and that of the incandescent lamp is so superior that a very different result is obtained. The efficiency of a 16 per cent. incandescent lamp being about 6 per cent., and assuming a mechanical efficiency of 80 per cent. for the gas-engines and 85 per cent. for the dynamos, including loss in transmission, it is found that about 25 thermal units would reappear as light out of a possible 3,100. So that in spite of the threefold transformation of energy introduced, the final result is increased 2·5 times. This ratio would of course be still further increased in the case of arc lamps. The value of these ratios, taking minimum values in the cases of electric generation by gas-engine power, are as follows:

Character of burner.		Percentage increase of candle-power obtainable by using a gas-engine to drive a dynamo supplying electric lamps, as compared with that obtained by burning the gas district.
Gas.	Electricity.	
		Per cent.
A good ordinary 5ft. gas burner, such as a Bengel burner.	An incandescent electric lamp, using 4 watts, per candle and giving 16%.	78
A Wenham lamp.	An arc electric lamp of same power as Wenham gas lamp.	227

The reason of this is that the chemical combustion of coal gas with oxygen yields a flame in which the undulatory vibrations of a sufficient frequency to become luminous are extremely few compared with the heat waves, whereas in a gas-engine it is these heat waves that are transformed into mechanical energy. The chief points of a gaso-electric system of distribution may be summed up as follows:

1. The generating station already exists and may be considered as an eccentric power-house.

2. The existing gas-mains are available; hence there is no question of a separate main network being laid as in the case of hydro—or æro—electric supply.

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3. The useful efficiency of gas is out of all proportion greater when utilised as a motive power than when burnt direct in burners, and this in spite of the extra transformations of energy introduced.

4. It is more than probable that under a system such as has been discussed above, the cost of maintenance, superintendence, and management expenses will be less than under conditions of independent electric supply.

5. By paving the way for the substitution of electric for gas lighting without conflict of existing interests, an incalculable benefit is conferred on the community.

Of course, the hydro-electric system may be treated from the same point of view if once hydraulic supply mains exist; but the present efficiency and character of high-pressure water motors do not suggest the possibility of any very great economy being effected. It must not be forgotten that Van Rysselbergh's claim to economy is based upon a motor efficiency of 80 per cent., which, though not unattainable, is very high and could not be relied on as an average result in practice; but for large private installations the energy supplied by the hydraulic power company could with advantage be utilised.

ELECTRIC LIGHTING AND PUMPING PLANT FOR MINING PURPOSES.

An electric lighting and pumping plant has recently been completed at Milnwood Colliery, Bellshill, N.B., for the Coltness Iron Company. The installation has been carried out by Messrs. Ernest Scott and Mountain, Limited, of Newcastle-on-Tyne, and it is one of the most complete laid down. The installation consists of the lighting plant for the colliery and for the miners' cottages, and pumping plant for pumping the water from the river.

The colliery lighting plant consists of an improved "Tyne" compound-wound dynamo, constructed so that it can either be used for the colliery lighting or for the lighting of the miners' cottages. To enable the machine to do this work the field magnets are wound in a special manner, so that when running the lights at the colliery the machine gives a constant E.M.F.; but by switching in an additional coil on the magnet, the machine can be used for lighting the lamps at the cottages, and gives a constant pressure at the cottages, whatever number of lamps there may be on the circuit. The current from the dynamo is taken to a main switchboard, which is fitted with two double-pole main switches, and is there divided into the two main circuits—*i.e.*, one circuit for the surface lighting and one for the underground lighting. The surface is lighted by four 2,000-c.p. arc lamps, working two in series over 100 volts, and suspended from poles fitted with wrought-iron head gears, with raising and lowering gears, consisting of a winch and the necessary length of stranded steel suspending rope. In addition to the arc lights there are about 100 incandescent lamps distributed about the pit-head, etc. These are all attached to substantial fittings, and a large number of branch circuits has been fitted, so that the lights can be switched on or off as required. About 30 incandescent lamps are used for the lighting of the underground; these are all attached to ceiling fittings with wire guards, and the current to these lamps is taken down the shaft by armoured cables.

The installation for the miners' cottages, of which there are 34, consists of a dynamo which is an exact counterpart of the machine used for feeding the lamps at the colliery. The current from the machine is taken to a main switchboard fitted with a double-pole main switch, and is then carried overhead by copper conductors suspended upon oil insulators. The total length of conductors, out and home, is about 1,500 yards. The cottages are lighted by 102 16-c.p. lamps—*i.e.* three lamps to each—the lamps in the sitting-rooms are fitted with raising and lowering gear, and switches are fitted to each lamp.

The pumping plant comprises a "Tyne" shunt-wound dynamo, constructed to give an output of 350 volts and 34 amperes. The current is taken to a double-pole main switch, and is then conveyed by overhead cable, the total length being 2,600 yards, to the pumps, which are placed in a pump-house by the river. The pumps are of the company's improved three-throw ram type, the rams being 6in. diameter by 9in. stroke, and the pumps are capable of delivering 120 gallons of water per minute when running at a speed of 40 strokes per minute. The three pump bodies are separate castings, each similar in design and interchangeable; each pump is fitted with a gland bushed with gunmetal, and the stuffing-boxes are also bushed with gunmetal. Suction and delivery valve-boxes are all separate castings fitted with gunmetal valves and seats, the valves being of extra large diameter to ensure an easy passage for the water, and each valve is fitted with an adjusting gear, so that the lift of the valve can be regulated The connecting pipes, both on the delivery and suction side, are also separate castings, and an air-vessel is fitted on the delivery branch. The object in constructing the pumps in this manner is to prevent any possibility of a total breakdown. In the cheaper type of pump it is customary to cast valve-boxes and pump body in one casting, the result being, if there is frost and the castings should be cracked, the whole pump is destroyed, whereas in the design of pump under consideration, in the event of any particular part being broken, the pumps are still capable of working, even with only one or two rams. The rams are of gunmetal, and are attached to slipper guides working in guide plates forming an oil-bath, and thus providing continuous lubrication. The connecting-rods, crankshaft and countershaft are of steel, all fitted with extra long bearings to avoid wear and tear. The power from the motor is transmitted to the pumps through a pair of spur wheels, a pulley being mounted on the outer end of the countershaft to receive the driving belt from the motor. The electric motor is of Messrs. Scott and Mountain's improved mining type, and is capable of giving 13 effective horse-power when running at 700 revolutions. A starting switch is provided, so that the motor can be stopped or started slowly, and all shock taken off the pumps. This plant has now been at work some time, and has given very satisfactory results.

ELECTRIC LIGHTING OF COLCHESTER.

REPORT BY MR. MASSEY.

At the monthly meeting of the Town Council last week, the Lighting Committee submitted the following report received from Mr. W. H Massey, as to (1) the practicability of supplying electric light for public and private purposes without incurring loss or increasing the rates, and (2) the best course to be adopted for carrying out the provisions of the Colchester Electric Lighting Order:

"I have carefully considered the various matters about which you did me the honour to ask my advice, and, having regard to certain transactions in the past, when I acted for some members of your Corporation, my recent investigation was purposely made more full than was necessary, perhaps, but it is not my intention to trouble you with a long report, and when we come to estimates of cost, I shall (in the best interests of your Council) give no more details than I can help My opinion eight years ago was that electric lighting in your borough could not be carried on at a profit by a company, and I am of that opinion now. In 1885-6 it was confidently expected by several firms, whose schemes were submitted to me, that an annual revenue of from 30s. to 40s. per 50-60 watt lamp would be obtained, and I had to take into account the fact that many large customers were then prepared to enter into contracts for the supply of current upon those terms. The cost of production has gone down very much since then, but we know from actual experience nowadays that one cannot depend upon more than 10s. per year per 30-40 watt lamp (fixed) in any provincial town, so that the prospects of earning dividends is almost exactly what it was.

"There is more bright weather and sunshine in Colchester than in any town I know of in England, and the revenue per lamp will be less there than in such a place as Southampton, which is in the hands of a company, or in Hull, where the Corporation electric light works are said to be already paying their way. I think Northampton may be taken as a guide in what should or should not be done at Colchester; but in order that the committee may have some means of judging for themselves, I enclose an analysis of the Board of Trade returns, which is printed each week in one of the technical journals, and I have marked certain portions of it so that your attention may be directed to figures which are not the less valuable for not being embodied as original matter in a report. You asked me to put the facts plainly before you, and I know that you will not be led away by anything you may have heard or read as to the cheapness of electricity produced under conditions seldom, if ever, to be met with in practice. If my views had not, in the main, been correct, you would ere this have receive applications for a transference to others of the valuable powers granted to you under a provisional order last year. But although a company might stand very little chance of being financially successful in Colchester, it does not follow that your Corporation would fail also. You are in a position to borrow money so cheaply that 5½ per cent. is sufficient for interest on and the repayment of a loan within the period (25 years) usually fixed by the Local Government Board, and nothing would have to be paid for promotion, or for such other purposes as are essential when a company tries to raise money. The salaries of a secretary and a clerical staff can be saved to some extent by judicious arrangement on the part of your town clerk, and the superintendence charges would be low if the electric light department could be placed under the borough engineer. Establishment and working expenses might be reduced to a minimum if only the various works of a corporation could be so combined that one staff might assist in running two or more things hitherto kept entirely distinct. This bears directly upon the question of sites, to which I shall allude presently, but I would venture to dwell for one moment longer upon a point generally lost sight of—viz., that in well-regulated institutions and on economically managed estates, some of which may well be compared to small towns, the same staff will attend to heating, ventilating, pumping, and waterworks, electric lighting, fire service, gasmaking, laundry work, sewerage, etc, and not only are the boilers and much of the machinery brought into the same buildings, in order that the running expenses shall be small, but the object of an engineer called in to prepare plans for, or to reorganise a comprehensive scheme of that kind, would naturally be to obtain efficient duplication of apparatus in a way that leads to a saving in first cost as well as in maintenance. I am aware of the difficulties of carrying out all corporation work on similar lines; but I submit to your committee, for their most serious consideration, the desirability of trying to run their electric lighting works (whenever they may be established) in conjunction with something else, so as to reduce expenditure of every kind, and to make the most of an advantage which a corporation undoubtedly possesses over any private or public firm endeavouring to carry on similar work.

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"I have, in company with the chairman of your committee, Mr. E. Thompson Smith (who has taken a good deal of trouble in this matter on various occasions when I have visited Colchester), inspected five sites—the waterworks, the water-tower, the milk factory, the Middle Mill, and vacant ground near the Corporation yards, and Mr. Goodyear, the borough engineer, has furnished plans and particulars which have been of great use to me.

"At the water-tower the cartage of coal would be dear, and condensing water in large quantities is not available. At the milk factory there is no machinery which I could recommend you to adopt for a modern electric light station, and it would cost nearly as much to strip and adapt the existing buildings as to erect new and more suitable works. At the Middle Mill there is water power sufficient for light day loads and all night work, but this power would have to be supplemented by steam for heavier loads, and unless the site could be bought very cheaply, the cost of carting coal to it, and the impossibility of combining any other scheme with that of electric lighting, to say nothing of the necessity for protecting the electrical machinery from the effects of floods, would have to set against the value of the water power available, and I think on the whole that you had better go elsewhere.

"At the waterworks site a combined scheme might still be arranged, so that steam power could during the day be supplied from a new set of boilers common to both undertakings, and a saving would thus be effected in the wages of the attendants. Coal is used there now, so I suppose the cost of hauling is not so prohibitive; but I fear that complications might arise as to the condensing water, and failing an agreement between the Waterworks and Lighting Committees, a combined scheme would fall through.

"A question as to the disposal of your town refuse having been raised, I paid a special visit with your chairman to the piece of land between the milk factory and the Corporation yard, where, I am informed by your borough engineer, water may be had in abundance for condensing purposes; and even if it should be necessary to lay a separate pipe to lead away the waste water so as to keep it out of your sewers, to save pumping at the sewerage works, I believe that upon this vacant ground you would be able to arrange for electric light works side by side with apparatus for burning refuse in a manner that would prove advantageous to the ratepayers. St. Botolph's Station is so near that coal could be delivered on this site as cheaply as at the milk factory. The price of the land is moderate, and some of the adjoining cottage property might be bought in to give additional space and facilities for dealing with the urban sanitary requirements.

"On receiving your committee's further instructions I shall be glad to prepare plans, in conjunction with Mr. Goodyear, which would, I hope, recommend themselves for your acceptance if it is decided to proceed with the electric lighting of Colchester.

"To provide only for the lighting of North-hill, Head-street, and High-street, as far as St. Nicholas's Church, by arc lamps, and for the supply of current to about 3,000 40-watt incandescent lamps out of a total of 4,000 or 5,000 fixed in the houses and shops in these streets, a total expenditure of nearly £13,000 would have to be incurred by the Corporation, and I am quite sure in my own mind that if the scheme is limited to this area (the compulsory area of the provisional order) there will be a difficulty in making the electric light pay its way, even in the hands of the Corporation; but if you are willing to take in portions of Crouch-street and St. John's street, of St. Botolph-street and Queen-street, so as to embrace an area in which it is reasonable to suppose 6,000 or 7,000 lamps would be fixed in houses and shops, I estimate that the total expenditure would be about £18,000. To this it would be wise to add £2,000 as working capital, so that a loan of, say, £20,000 would be required.

"The amount to be set aside for interest and repayment would be £1,100 per year, and the scheme would become self-supporting as soon as a gross yearly rental of £2,000 (including £300 for street lighting) could be obtained.

"*Systems.*—It appears to me improbable that there will ever be any great extensions to portions of the borough far distant from the compulsory area, and the system I should recommend, therefore, is the low-tension three-wire system (or some modification of it), if the site near the Corporation yard is chosen; but if your committee are of opinion that provision should be made for future extensions to a distance, my scheme would have to be modified somewhat, without, however, the question of total expenditure being very much affected. If either the waterworks site or the Middle Mill site be selected you would have to adopt the high-tension alternating-current system, because the stations would then be outside the area of supply; but in these cases also the figures I have given would hold good, the only difference being that the running expenses would be a trifle higher than those in the low-tension scheme for which I have worked out the details."

The committee proposed, in accordance with a suggestion made by Mr. Massey to the chairman, and with a view to ascertaining the probable number of lamps to be supplied with light, to send a circular to the occupiers of premises situated within the large area specified in the report, giving information in regard to the probable cost of the light, and enquiring whether such occupiers are prepared to avail themselves of the supply, and if so, to what extent. The committee hoped that they may be in position to make a recommendation to the Council at its next meeting.

Mr. Thompson Smith moved the adoption of the report, which he said was a very able one, and would require a good deal of consideration. The committee, as stated in the report, proposed to take certain steps with a view to ascertaining the desires and wishes of the inhabitants of those parts of the borough which were proposed to be lighted, and till those wishes were ascertained it would be far better the matter should be left in the hands of the committee.

The adoption of the report was agreed to.

COMPANIES' MEETINGS.

SOUTH STAFFORDSHIRE TRAMWAYS.

An extraordinary general meeting of this Company was held on Tuesday at the Cannon-street Hotel, E.C., for the purpose of electing directors and auditors.

Mr. W. S. Schuster was voted to the chair, and said that the meeting was purely formal. The petition presented for the winding up of the Company, with a view to its reconstruction under the Court, was adjourned by Mr. Justice Vaughan Williams to give the shareholders an opportunity of expressing their views upon it. Since then the present directors had signified their intention to retire, in order that a new Board might be constituted; and, under these circumstances, the petition would not be proceeded with. The new Board, he said, was entirely unfettered so far as regarded the enforcement of claims against the late directors or other persons connected with the Company, and its policy would be to come, if possible, to some all-round compromise and arrangement by which the line could be taken out of the hands of the receivers and placed upon a permanent basis. If satisfactory arrangements could not be brought about, the new Board would recommend the shareholders to litigate or wind up. Investigations made for the purpose of litigation had thrown a great deal of light upon the history of the Company, and it was not proposed, having regard to possible future litigation, to introduce the matter into the meeting, although the fullest information would be given to any shareholder who liked to apply for it privately.

In reply to a shareholder, **Mr. Elliott** said it was probably within the knowledge of the meeting that some time ago a petition was presented for winding up, alleging various acts on the part of the directors and others connected with the Company as grounds for so doing; but the judge, after reading the affidavits, said his opinion was that the matters stated in them were not grounds upon which he could order the winding up.

Mr. Munns said it was hoped that when the new Board was appointed some settlement would be come to with the debenture-holders, which would take the line out of their hands, and also with the Electric Construction Corporation, by means of which the charges which the Company was liable to pay under the contract would be modified.

Resolutions were then adopted accepting the resignations of the directors, electing Messrs. W. S. Schuster, S. R. Blundstone, and A. Dawson as a new Board, and appointing Messrs. Spain and Hardcastle as auditors.

SWAN UNITED ELECTRIC LIGHT COMPANY, LIMITED.

The shareholders in the Swan United Electric Light Company, Limited, unanimously agreed yesterday (Thursday) afternoon to a resolution that the Company should be voluntarily wound up, and Mr. H. C. Gover, of 100, Victoria-street, Westminster, was appointed liquidator. Mr. Gover was authorised to carry into effect upon the terms of a provisional agreement a sale of the Company's undertaking to the Edison and Swan United Electric Light Company. Mr. J. Staats Forbes, who presided at the meeting, made one of his characteristic speeches. He gave a historical account of the proceedings that had led to the decision that it was far better to amalgamate the two companies than to continue to work separately. The Swan Company held 60 per cent. of the shares in the Edison Company, and the residuum of the former's business was to be sold to the latter for £100,000 worth of debenture stock, to be distributed among the shareholders of the Swan Company. The fully-paid shares would receive three fully-paid Edison and Swan shares for every five fully-paid shares in the Swan Company, and about £1. 4s. in debenture stock in respect of each fully-paid share in the Swan Company. Partly-paid shares would receive about three partly-paid shares in the Edison Company for five partly-paid shares in the Swan Company and about 19s. 3d. in debenture stock in respect of each share.

ELECTRO-CHEMICAL COMPANY.

The statutory general meeting of the Electro-Chemical Company, Limited, was held on Tuesday at the Cannon-street Hotel, E.C.

Colonel Holland, C.B., presided, and stated that 16,745 preference shares, representing £83,725, together with 14,000 ordinary shares, representing £70,000, had been allotted, making in the aggregate a total capital of £153,725. Further applications from preference shareholders were still coming in, and were being considered as they were received. The Board had ample capital subscribed for all the requirements of the Company. The purchase of the Company's patents was completed, and they were in course of being transferred to the Company. Up to the present time, however, no money had been paid to the vendor, he agreeing to take £25,000 out of the £30,000 to be paid to him in shares. It was proposed at first to lay down machinery to manufacture annually 5,000 tons of caustic soda and bleach. Negotiations were in progress for the sale of some of the foreign patents. They had every reason to believe that by the new process they would be able to manufacture caustic soda at 50 per cent. less than

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the market price. The patents had been carefully secured to the Company.

On the motion of **Mr. Marcus**, Colonel Holland's election as a director of the Company was confirmed.

COMPANIES' REPORTS.

ELECTRIC AND GENERAL INVESTMENT COMPANY, LIMITED.

Directors: George Herring, Esq., chairman; the Right Hon. Lord Cloncurry; J. R. Braithwaite, jun., Esq.; B. H. Van Tromp, Esq.; Emile Garcke, Esq., managing director.

Report of the directors to be submitted to the fifth ordinary general meeting of the shareholders to be held at Winchester House, Old Broad-street, E.C. (Room No. 47), on Tuesday, June 26, 1894, at 3 p.m.

The directors beg to submit the balance-sheet and profit and loss account for the year ended May 31, 1894. The profit and loss account shows a gross profit on the transactions of the year (including the balance of £65. 16s. 5d. brought forward from last year) of £10,735. 6s. 8d., and after deducting all standing charges, and the interim dividend already paid on the ordinary shares, there remains a net balance available for distribution of £7,369 10s. 4d. The directors now recommend the payment of a further dividend upon the capital paid up on the ordinary shares at the rate of 40 per cent. per annum for the past six months, and a dividend on the founders' shares of £30 per share for the year. This will leave a balance of £369. 10s. 4d., which the directors recommend should be added in equal moieties to the ordinary and founders' reserve funds. The directors who retire this year are Mr. G. Herring and Mr. B. H. Van Tromp, but being duly eligible, offer themselves for re-election. The auditors, Messrs. Rait and Kearton, also retire, but offer themselves for re-election. It is proposed to make the dividends payable on June 27, 1894.

Dr. BALANCE-SHEET, MAY 31, 1894.	£	s.	d.
Capital authorised — £200,000 in 39,900 ordinary shares of £5 each, and 100 founders' shares of £5 each.			
Capital subscribed—20,000 ordinary shares, 100 founders' shares.			
Capital called up—£1 per share on 20,000 ordinary	20,000	0	0
£5 per share on 100 founders ...	500	0	0
	£20,500	0	0
Reserve fund—founders' shares	10,133	5	4
Reserve fund—ordinary shares	10,133	5	5
Provision for contingencies	8,000	0	0
Loan account	2,500	0	0
Sundry creditors	3,680	2	11
Unclaimed dividends	5	1	8
Balance of profit and loss account	7,369	10	4
	£62,321	5	8

Note.—There is a contingent liability amounting to £35,431. 5s. in respect of calls that may become due on securities held by the Company.

Cr.	£	s.	d.
Investments at cost	50,552	10	3
Sundry debtors	918	3	6
Cash in hand and on current account at bankers £712 4 11			
Ditto—dividend account 5 1 8			
	717	6	7
Founders' reserve fund, amount invested	10,133	5	4
	£62,321	5	8

PROFIT AND LOSS ACCOUNT YEAR ENDED MAY 31, 1894.

Dr.	£	s.	d.
General charges, including directors' fees, and additional remuneration as per articles of association, salary managing director, general expenses, legal charges, advertising, printing, and auditors' fee, etc.	2,365	16	4
Interim dividend paid December 1, 1893, at the rate of 10 per cent. per annum for the six months	1,000	0	0
Net profit available for division	7,369	10	4
	£10,735	6	8

Cr.	£	s.	d.
Balance from last year	65	16	5
Interest, dividends, commissions, and sundry profits (after providing for contingencies)	10,669	10	3
	£10,735	6	8

Baird, Thompson, and Co., Limited.—This Company has been registered with a capital of £60,000, in £5 shares, to acquire the business of Baird, Thompson, and Co., and to carry on the founding and working of iron, brass, and other metals, ventilation, heating, draining, and sanitation of buildings and streets, towns, shops, etc., pneumatic and hydraulic engineering, the destruction of town refuse, electricity and electrical engineering.

BUSINESS NOTES.

Western and Brazilian Telegraph Company.—For the past week the receipts were £2,576.

Maidenhead.—Electrical communication has been established with the dwellings of the firemen.

Poole.—The Board of Guardians have accepted the tender of Messrs. Bayley and Sons for the supply of electric bells.

Liverpool Overhead Railway.—The traffic receipts of this railway for the week ended 10th inst. amounted to £843.

Commercial Cable Company.—A quarterly dividend at the rate of 7 per cent. per annum has been declared, payable July 2.

Tenders for St. Pancras.—The tenders for the erection of generating station buildings for the St. Pancras Vestry are to be sent in by Monday.

Fleetwood.—October 20 is the date upon which the Board of Trade have fixed as the limit of time under the Fleetwood Electric Lighting Order, 1890.

Bristol.—Messrs. Henry Naish and Son have rebuilt their bacon factory in West-street, and the new buildings have been fitted throughout with the electric light by Messrs. Scull.

Cruto Incandescent Lamp Agency, Limited.—This Company has been registered with a capital of £5,000, in £1 shares, to carry on business as electricians, mechanical engineers, etc.

Oxford.—On the occasion of Lord Salisbury delivering the opening address at the meeting of the British Association, the Sheldonian Theatre will be specially lighted by electricity.

Baslow.—Mr. E. Scott Anderson, consulting engineer of Sheffield, has informed the Baslow Local Board that the water power available is sufficient for the supply of electric light to the town.

Salisbury.—An electric charging station has been opened at 100, Bedwin-street by Mr. E. R. Dall, A.I.E.E., for charging all kinds of portable accumulators for police, cycle, carriage, and other lamps.

Eccles.—The Town Council have authorised the Electric Lighting Committee to visit Whitehaven for the purpose of obtaining information on the subject of the lighting of the streets by electricity.

Launcestown.—The Western Electrical Company have written to the Launcestown Town Council offering to purchase the existing waterworks for electric lighting purposes, but the Council have taken no action in the matter.

Newgas and Co. v. the Gulcher (New) Electric Light Company.—Mr. Justice North has made an order in this debenture-holders' action for the appointment of a receiver of the property of the defendant company.

Post Office Telephones.—The new Post Office telephone, devised under instructions given by the chief engineer to the Post Office, is now being manufactured by the Consolidated Telephone Construction and Maintenance Company, Limited.

Chiswick.—The Chiswick Local Board have referred to a committee the plans sent in by Messrs. Bourne and Grant, the holders of the provisional order for lighting the district, of the proposed buildings and engines at the generating station.

Electrophone, Limited.—This Company has been registered with a capital of £20,000, in £5 shares, to acquire the undertaking of the Electrophone Syndicate, and to carry on the business of telephonic and electrical apparatus manufacturers.

Public School Lighting.—Messrs. Allpress and Co., of 55, Victoria-street, Westminster, are now fitting up the electric light and machinery required for generating the current at the Tonbridge Schools, belong to the Skinners' Company, at Tonbridge, Kent.

St. Austell.—The Local Board have received a letter from Messrs. Veale and Co, Limited, respecting the electric lamp on the fountain. Mr. Hicks has given notice that at the next meeting he will move that the resolution passed on the subject on May 8 be rescinded.

Tenders for Cheltenham.—Tenders are invited for the supply and delivery of electric lighting cables for this borough. Particulars are given in our advertisement columns. The tenders for the erection of a central station for the Town Council are to reach the town clerk not later than Tuesday next.

Maidstone.—At the last meeting of the Local Board, Alderman Long remarked that the Board's electric lighting order expired in a few weeks. He would like to know what the committee were doing. In reply, the Deputy Town Clerk stated that they were waiting for a reply from a company in London.

Dover.—The surveyor reported to the Town Council last week that he had received notice from the electric light company that all the boxes were in on the sea-front except one transformer-box. They had also given notice that they intended to lay the mains down from the Market-square to the Town Hall.

City and South London Railway.—The receipts of the Company for the week ended June 10 were £911, against £759 for the same period last year, or an increase of £152. The total receipts for the first half-year of 1894 show an increase of £671 compared with those for the corresponding period of 1893.

Electric Crane and Generating Plant.—The tender of Messrs. J. G. Statter and Co., 68, Victoria-street, S.W., has been accepted for the electric crane and generating plant at the works of Messrs.

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C. H. Glover and Co., Hatcham Sawmills, S.E, to whom Mr. E. R. Dolby, of Westminster, is acting as consulting electrician.

Tenders for Gas-Engines.—The Council of the borough of Reigate invite tenders for the supply and erection of two Atkinson Cycle gas-engines, with heavy flywheels, starting valves, water-tanks, piping, connections, and foundation bolts. Tenders are to be delivered at the office, 84, Station-road, Redhill, Surrey, by 25th inst.

Belfast.—At a meeting of the Electric Lighting Committee a few days ago, the engineer reported the progress made in the works since the last meeting. A letter was read from Prof. Kennedy intimating his intention to visit Belfast to go over the works with the resident engineer, and to consult with the resident committee.

Bournemouth.—The Town Council have passed the following plans sent in by the electric supply company: new main from Queen's-road to Branksome Wood-road; transformer pits in Commercial-road and the Triangle; altered service to transformer pit at Lansdowne; and new cast-iron cable duct from Poole-hill to the Square.

Nottingham.—A public meeting has been held for the purpose of considering the desirability of promoting tramways to serve the Woodborough-road and Mapperley Plain districts. A committee was appointed to ascertain whether the haulage would best be by cable or by electricity, the probable cost and income, and all other necessary particulars.

Tenders for Aberdeen.—As stated in our last issue, the President and Governors of Robert Gordon's College in Aberdeen invite, by the 19th inst., tenders for the supply of materials, and the wiring of Robert Gordon's College; the supply of two 1-h.p. electric motors; and the supply of materials and the wiring of Gray's School of Arts.

Shrewsbury.—The Board of Trade Provisional Order Bill, empowering the Shropshire Electric Light and Power Company to provide electricity and supply current through the mains to consumers by meter in Shrewsbury, has passed the Examiner on Standing Orders in the House of Lords, and has been ordered to be reported for second reading.

Tenders for Railway Stores.—The Highland Railway Company are asking for tenders for the supply of telegraph instruments and fittings and telegraph construction material. Forms of tender may be obtained on application to Mr. J. G. Bulmer, storekeeper, Inverness. Tenders must be lodged with Mr. And. Dougall, secretary, Inverness, by 23rd inst.

Acton.—The Local Board have received a letter from Mr. Medhurst acknowledging the clerk's intimation that the Board desired to terminate the negotiations with him for the taking over of the Board's electric lighting order. As no replies have been received to the advertisement for purchasers of the provisional order, the Board have resolved to advertise again.

Nelson.—At a meeting of the Town Council the Gas Committee resolved that, subject to provision in any agreement, all consumers of electricity should be charged per meter. Answering Councillor Spencer, Alderman Wilkinson said that unless there was an agreement to the contrary previously made, all consumers of the electric light would be put on meter whether they were willing or not.

Plymouth.—In the House of Lords on Tuesday the Bill confirming the provisional order of the Board of Trade authorising electric lighting at Plymouth was ordered to be read a third time. In connection with a Bill conferring powers on Veale and Co. for the electric lighting of St. Austell and district, the examiner has been satisfied that the Standing Orders have been complied with.

St. Luke's.—The St. Luke's Vestry have decided, in consequence of the County of London and Provincial Electric Lighting Company having agreed not to offer any opposition to the St. Luke's Vestry, should they at some future time determine to apply for a provisional order to supply electric light in the parish, to inform the Board of Trade that they see no objection to the company carrying out the work of lighting the parish.

Strand.—The Strand District Board of Works have adopted a special report of the Works Committee on a memorial from the Charing Cross and Strand Electricity Supply Corporation, which proposed to supply electricity in the parish of St. Paul's, Covent Garden, at £26 per arc lamp of 2,000 c.p. The committee expressed the opinion that if competitive powers were granted to a second company, they should apply to the district as a whole and not to one parish.

Accepted Tenders.—The tender of Messrs. W. Gradwell and Co., of Barrow-in-Furness, has been accepted for the erection of the electric light station at Newport (Mon.), and that of Mr. C. Haywood, junior, has been accepted for the erection of a generating station and depôt at Foleshill, for the Coventry and District Tramways. Messrs. Vaughan and Brown have received the contract for the wiring of The King's Arms, Bishopsgate-street Without, E.C.

Newport (Mon.).—The committee of the Newport Corporation having charge of the electric lighting project have decided that the charge to consumers shall be as follows: under 1,000 units per quarter, 6d. per unit; above 1,000 and under 2,000 units per quarter, 5½d. per unit; above 2,000 units, 5d. per unit. It has been decided that all corporate buildings, such as the Town Hall, free libraries, markets, baths, slaughter-houses, etc., shall be lighted by electricity.

Llandudno.—Mr. William Kingsland, A.I.E.E., electrical engineer, has recently removed from Clarence-buildings to new premises at 139, Mostyn-street. Mr. Kingsland and Mr. R. Bellis are pushing on with their scheme for giving Llandudno the benefit of a central electric supply station, and thus bringing it up to date with other first-class watering places. A strong directorate has been formed, and the Llandudno Electric Supply Company, Limited, will be registered in a few days.

West's Gas Improvement Company, Limited.—This Company has been registered with a capital of £100,000 in £20 shares. The object is to acquire the business of manufacturers of machinery and apparatus connected with the manufacture, purification, storage, distribution, and employment of gas, as hitherto carried on by the West's Gas Improvement Company, Limited, at the Albion Ironworks, Miles Platting, Manchester, and to carry on business as gas, electrical, and mechanical engineers.

Woodhouse and Rawson, United.—In the matter of Woodhouse and Rawson United, Limited, the public examination of Lord Aberdare, Sir R. W. Rawson, Sir John Stokes, Samuel Pope, Q.C., F. L. Rawson, W. T. Stutchbury, Albert Hoster, T. H. Lambert, C. L. Baker, A. L. Foley, J. H. Owen, Malcolm Dundas, — Mumford, Philip Rawson, and F. W. Pixley has been fixed for the 18th inst., and two following days, before the Registrar, at Bankruptcy-buildings, Carey-street, Lincoln's-inn, W.C.

Brighouse.—Messrs. Sharpe, Parker, Pritchards, and Barham, Westminster, solicitors and parliamentary agents, have been appointed by the Town Council to act for them in the promotion of the Bill in Parliament during the ensuing session for the purchase of the undertaking of the Rastrick Gas Company, electric lighting, and other municipal matters. A good many business houses in this district are now supplied with the electric light by Mr. A. B. Brook, who has put down a plant in Hall-street.

Aberdeen.—The question of the lighting of the new police buildings by electricity has been discussed at a meeting of the Watching and Lighting Committee of the Town Council. An estimate was submitted, which showed that the cost of carrying out the scheme would be £250, but it was explained that £100 would be saved on gas fittings, so that the net extra cost over gas would be £150. The proposal met with general acceptance, but it was agreed to defer further consideration till next meeting.

Ayr.—At a meeting of the Municipality a letter was read from the Ayr Harbour Trustees desiring to know what the Commissioners would charge for supplying eight arc lamps 3,000 c.p. for the north side of the river and dock, and four arc lamps with similar power for the south side of the harbour. The application had been forwarded to Mr. Hammond, who advised that the Harbour Trustees should be supplied with electricity at the rate of 4d. per unit, they providing the lamps and other plant required in connection with the installation.

Ship-Lighting.—Messrs. Charles Connell and Co., Whiteinch, Glasgow, have launched from Scotstown Shipbuilding Yard a large and fully-equipped steel screw-steamer for Messrs. Greenshields, Cowie, and Co.'s Knight Line, of Liverpool. For expeditious working of cargo, she has seven hatches and seven of Messrs. Clarke, Chapman, and Co.'s steam winches, and when it may be necessary to work at night she is supplied with a cluster of electric lamps to illuminate the decks. The vessel has a complete installation of electric light, carried out by Messrs. J. H. Holmes and Co.

Lighting of the City.—Mr. Ross, who was last week appointed engineer to the Commissioners of Sewers, has issued a report on the subject of the works executed by the Commission during the past year. With regard to electric lighting, Mr. Ross remarks that main thoroughfares to the extent of 13 miles are now lighted by arc lamps. At the end of the year the number of gas lamps unlit was 1,315, and the number of arc lamps lighted was 479—in other words, 2·74 gas lamps were extinguished for each arc lamp. The failures of the arc lamps during the year were not numerous; the percentage of time during the last six months being ·046, or one hour in 2,100.

Result of Islington Tenders.—The number of tenders received by the Islington Vestry for the supply of electrical plant was over 200. The accepted tenders are as follows: Boilers and engines, steam-pipes, pumps, etc., D. Adamson and Co., Dukinfield, Manchester, £8,614. 4s.; water-tube boilers, Babcock and Wilcox, London, £1,170; alternators and switching gear, J. Fowler and Co., Leeds, £3,925. 5s.; instruments, Elliott Bros., 101, St. Martin's-lane, W.C., £830; conduits, British Insulated Wire Company, Prescot, Lancs., £4,333. 4s. 2d. The arc lighting section, including engines and machinery, and also the cables, have not yet been decided.

Douglas.—A meeting was held on Wednesday of the shareholders of the Isle of Man Tramways Company, Douglas, to confirm a resolution passed at a meeting in May to wind up the Company voluntarily, the secretary (Mr. Young) being appointed liquidator. This resolution was unanimously confirmed by the meeting on Wednesday. The winding up of the Company is the consequence of its assets and interests in the tram lines leased from the Town Commissioners having been bought up by the new Douglas and Laxey Tramway Company for £36,000. The price which the Company have obtained for their property will amount to £1. 10s. 4d. for the ordinary £1 shares, which some years ago could have been bought for 6s. or 7s. each.

The Edison-Bell Phonograph.—Judgment has been given in the Court of Appeal in the appeal of the defendants from the judgment of Mr. Justice Wright, in February last, in the action of the Edison-Bell Phonograph Company *v.* Smith and another. The Master of the Rolls dealt with the defendants' objections to the various claims set up for plaintiffs' patent. He agreed with every part of the judgment of Mr. Justice Wright, and he could not disagree with his finding as to matters of fact; therefore, in his final judgment he entirely agreed with him, and he thought

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that the present appeal had substantially failed in every respect, with the exception of the minor amendment as to relief. The defendants must pay the costs of the appeal. Lord Justices Kay and Smith concurred.

Newcastle.—The city engineer has presented to the Finance Committee a statement as to the probable cost of painting the Town Hall, introducing heating apparatus in the building and lighting up the hall with the electric light. He reported that the painting of the building would cost £430; heating the place, £410; and the installation of the electric light, almost £470. It was decided that the report should be considered at the next meeting of the committee. The Town Council have received the report of the special committee appointed to consider the desirability of the Corporation undertaking the provisions of electricity in the city. The report, which is in favour of the Corporation undertaking this work, was adopted by the Council on Wednesday, and £200 is to be spent in getting information on the subject.

Glasgow.—The Electric Committee of Glasgow Town Council have had before them the proposed extension of the generating plant in the central station in Waterloo-street, the laying of additional distributing mains in the western district of the city, and the application by the Police Commissioners to have several additional streets within the city lighted by electricity. They have remitted to the engineer to prepare a plan, showing what further plant can be accommodated within the Waterloo station, and the probable cost of putting down the same. They have meantime delayed the matter as to supplying current for additional street-lighting until it is ascertained from the annual financial statement what has been the average cost to the Corporation of supplying each of the arc lamps for street-lighting at present in use.

Worthing.—The Electric Light Committee reported to a meeting of the Town Council last week that they had received replies to an interrogatory circular sent to 52 town clerks. The chairman (Councillor Raffety) was requested to obtain the opinion of an expert as to the probable cost of such works and machinery as are requisite to enable the Council to supply electricity for street lamps and to private persons. It was resolved that the chairman, with the mayor and town clerk, should prepare and send a circular to the inhabitants of the borough, inviting them to state whether they are prepared to take the electric light in the event of the Town Council being in a position to supply it. The Council were recommended to direct the committee to take the necessary steps to enable them to apply to the Board of Trade for a provisional order.

Colchester.—The Public Library Committee have reported to the Town Council that they have been in negotiation with Messrs. Christy Bros., of Chelmsford, as to lighting the library by electricity. Messrs. Christy tender to supply the requisite electrical energy at the rate of 8d. per unit, but state that, as they will have to make a very large capital outlay for electric accumulators, they can only undertake the lighting on condition that the Council take the supply for a minimum term of three years. It is calculated that the consumption, with reasonable economy, will be from 1,400 to 1,500 units per annum, at an expenditure of about £50, which will be very little, if any, dearer than gas in similar circumstances. Messrs. Christy also tender to supply and fix the necessary fittings for £28. 4s. The committee recommended the Council to accept the tenders. The report was adopted by the Town Council after some discussion.

Sunderland.—At Wednesday's meeting of the Town Council, on the receipt of the report of the committee on electric lighting, a long discussion took place with regard to the appointment of a resident electrical engineer. The committee submitted the names of the following selected candidates: C. S. V. Brown, 27 years of age, resident engineer, the London Electric Supply Corporation, Stowage Wharf, Deptford, London; John F. C. Snell, 26 years of age, assistant engineer, St. Pancras Vestry's Central Station, London. Alderman Fairless moved that the portion of the report be sent back to the committee, and he contended that they should have the candidates before them, and then make a selection. Eventually it was decided that the two gentlemen named, together with a third, a Mr. Brown, the three recommended by Prof. Kennedy, be invited to wait upon the committee, and that the committee should then elect one of them.

Edinburgh.—At the meeting of the Town Council on Tuesday the treasurer stated that of the capital expenditure of the Lord Provost's Committee there was an increase of £1,580 for electric lighting. There was an estimated charge of £4,785 for electric lighting. Mr. Mackenzie explained that the reason for the large increase in the estimate for the electric lighting station at the West-end was that the committee had decided to make provision for extension at the outset, in order to save the very great expense of enlarging the station, probably within a year. Mr. Cranston, in connection with certain payments to the National Telephone Company by the Plans and Works Committee, took occasion to refer to what he called the very bad service that was given in the town by the telephone company. It was perfectly disgraceful. He did not think any city was so badly served. The telephone company got many advantages from the city, and they gave a poor return for it.

Leeds.—At a meeting of the Sanitary Committee of the Leeds Corporation, the question of erecting boilers of 550 h.p. at the Meanwood-road destructor was considered. The matter was brought before the committee by the city engineer (Mr. Hewson), and it was pointed out that boilers of the power suggested might be utilised for the purposes of electric lighting, or for electric traction or cable traction on the tramways. A sub-committee was appointed to consider the question. It appears that the electrical plant in the Leeds Municipal Buildings is likely to be removed. At a meeting of the Corporate Buildings Committee, a sub-committee was appointed to consider the advisability of having a plant fixed near the destructor, where, it is thought, it could be utilised for other purposes as well as for furnishing the electrical supply required for lighting the Municipal Buildings and Town Hall. An alternative suggestion has been made that the Corporation should obtain their supply from the Yorkshire House-to-House Electric Lighting Company.

Blackpool.—It is expected that the electric tramway will be completed for traffic very shortly. A test of the new portion of the line between the Cocker-street terminus and Foxhall-road has proved satisfactory, and the leakage of current is reported to be very small. Mr. M. Holroyd Smith has been instructed to refuse all tramway boxes not supplied in strict accordance with his orders and drawings. Mr. Thos. Parker has been asked to accept a sum of £10. 10s. in respect of his inspection and report upon the Corporation tramways in December last. Tenders are to be procured for the rails and other ironwork required for the proposed tramways in Lytham-road, and the town clerk has been authorised on behalf of the Corporation to give all necessary notices to companies or persons in connection with the laying of the proposed tramways in Lytham-road. Mr. M. Holroyd Smith has also been authorised to obtain designs and estimates from various makers for the motors and gearing required for the two new large tramway bogie cars now being built by the Lancaster Wagon Company.

Stafford.—The report of the Electric Lighting Committee was presented for adoption by Alderman W. H. Peach at a meeting of the Council last week. He stated that the foundation for the chimney stack had been prepared and 25 pitch-pine piles had been driven and firm ground reached. Similar foundations would be made for the engine and dynamo house. After detailing several minor alterations in the contracts, Alderman Peach drew attention to some remarks in the Birmingham City Council as to the competition between electricity and gas in the Market Hall ward, where a company provided the electric light. In that ward there had been a considerable decrease in the consumption of gas, due to the use of electricity. It was remarked at the meeting referred to that the competition of the electric light was seriously checking the consumption of gas, and the application of electricity to illumination would continue to grow. The Birmingham Corporation would eventually have to buy out the electric lighting company at an exorbitant figure. He mentioned this as a justification of the course they had pursued at Stafford. The report was adopted.

Southport.—At Tuesday's meeting of the Town Council, Alderman Hocking, in moving the minutes of the Gas and Electricity Committee, called attention to a resolution to the effect that the price of electric energy for the first year from the opening of the works be 7d. per unit, being one penny less than the maximum allowed by the provisional order. Councillor Hesford seconded the adoption of the minutes. Councillor Kerr moved, as an amendment, that the price be 6d. per unit. Having studied the subject, he had come to the conclusion that the action of the committee, if endorsed by the Council, would considerably decrease the consumption of electrical energy for some years. Councillor Hough seconded the amendment. Councillor Travis explained that the question had been carefully considered by the committee from various standpoints. They came to the conclusion that there was no reason to believe they could make any profit by supplying electricity at 6d. per unit. It was hoped that in the course of a short time the committee would be able to make important concessions to large consumers. Having heard this explanation Councillor Kerr withdrew his amendment, and the minutes were adopted as recommended.

Derby.—A number of members of the Midland and South Midland branches of the National Association of Colliery Managers lately visited Derby and viewed the works at the electric lighting station. Mr. Stewart (manager of the works), together with members of the staff, conducted the company round the station, explaining to them in detail the working of the machinery and apparatus. After staying an hour at the electric lighting station, Mr. Stewart conducted the company to the electrical exhibition at the Lecture Hall. The chief event consisted of a demonstration by Messrs. Pyke and Harris, electrical engineers, of London, with high-tension apparatus. Some brilliant illuminations were produced, and in many ways the power of electricity was shown. The company included Mr. Douglas (president of the Midland branch), Mr. J. Ashworth (Chaddesden, vice-president), Mr. T. Severn (Nottingham), Mr. Blower (Newton), Mr. J. H. W. Loverock (Riddings), Mr. Wheatley (Nailstone), Mr. Allsopp (Pinxton), Mr. Miles Hardwick (Napperley), Mr. Hodgson (Coton Park, Burton), Mr. Allsopp, jun. (Pinxton), Mr. Jno. Eaton, Mr. T. G. Lees (Nottingham, secretary of the Midland branch), Mr. J. H. Pragnell (Derby), Mr. Alfred Eley (Swadlincote), Mr. Belfitt (Bretby), Mr. F. P. Hewitt (Swadlincote, secretary of the South Midland branch), Mr. A. Knighton (Bagworth), and Mr. Hewitt (inspector of mines).

Radcliffe.—At a meeting of the Local Board, Mr. Cunliffe moved that application be made to the Board of Trade for a provisional order for the supply of electricity for any public or private purpose within the area of the Board's district. He said the desirability of having the electric light was becoming more evident each year, owing to the high price of gas in the district and its inferiority to electricity as an illuminant. The committee appointed by the Board had visited several towns where electric lighting was in operation and that successfully—not only

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from a useful but a monetary point of view. It might be suggested that their Board should defer the matter until the District Council came into existence. In this, as in many other matters, delays were dangerous, and they were not too soon. There were many reasons why electric lighting should be introduced. He thought it would be advantageous to shopkeepers, and it would most certainly be so to the dyeworks. Gentlemen engaged in the dyeing and embossing trades had informed him of the great value of the electric light in a district like Radcliffe. Though electric light in its present form had only been going on during the last 16 years, £5,125,000 had been laid out for it. Many local authorities were using it, a large number had schemes in hand, many private companies had been formed, and he had no doubt of its value. For the lighting of the streets it would be very serviceable, and he considered they would be only recognising the interests of the town in seeking the provisional order. Mr. Richard Walker seconded the motion. The resolution was carried unanimously.

Bolton.—The scheme prepared by the electrical engineer (Mr. J. H. Rider) for carrying into effect the supply of electric fittings on the hire-purchase system has been considered by the Gas and Electricity Committee of the Town Council, and it was resolved that the scheme be adopted and that the town clerk be requested to prepare a form of agreement to be entered into by persons having such fittings on the hire-purchase system. The engineer submitted an estimate of the cost of the extension of the electric mains into Newport-street, and it was resolved that the works requisite for such extension be carried out. It was also decided that the tender of Messrs. Siemens Bros. for the laying of the requisite cables for such extension be accepted, and the chairman was authorised to arrange for the construction of an additional transformer-chamber at the corner of Newport-street and Great Moor-street. The four mills in Flash-street belonging to Messrs. Ormrod, Hardcastle, and Co., Limited, are about to receive an electric light installation. The plant consists of one large dynamo, capable of lighting 1,300 lamps, and is driven at a slow speed off one of the mill engines. In addition is a small pilot dynamo of 100 lights capacity, arranged to be run off the same shaft or from a small auxiliary engine, as may be required. The current from both machines is regulated at a main switchboard, and is conveyed by four main cables to the four mills and distributed through local switchboards to the various rooms. The contract has been let to Messrs. Bennett and Druce, of Preston, and the designing and arrangement of plant has been carried out by Messrs. Shepherd and Watney, consulting engineers, Leeds.

Electric Lighting of St. Pancras.—The chairman of the Electricity Committee of St. Pancras Vestry (Mr. A. Sweet) made his annual report to the Vestry on Wednesday. He described the past year's business as satisfactory. The total income was £15,022, sufficient to clear off the deficit of the first year—£1,543—and, after paying all the working expenses and £927 in maintaining the works in the highest state of efficiency, to leave a balance of £4,669, out of which interest and repayment of loans had been met. The extension now nearing completion at Stanhope-street station and the station in course of erection at King's-road would, it was hoped, be in working order and available by next winter. The ratio of cost for public lighting for the year by electricity, as compared with gas, was high, but the charge of 6d. per unit made for public lighting was certainly less than a company would charge under similar conditions, and from Michaelmas next the charge would be reduced to 5d. per unit. The supply of electricity to private houses, though not large, was promising, as the number of consumers had doubled during the year. The report was adopted, and the chairman thanked for his services. A letter was then read from the Gaslight and Coke Company announcing that from the close of the current quarter the price of gas supplied for public lighting would be increased from 2s 2d. to 2s. 4d. per 1,000 cubic feet. The Vestry passed a resolution emphatically protesting against the increase, and Mr. Sweet (the chairman of the Public Lighting Committee) said the Vestry could checkmate the company by lighting all the main streets with the electric light, which they would shortly be able to do.

Lighting of Birkenhead.—The Finance Committee recommended at a meeting of the Town Council last week that application should be made to the Local Government Board for sanction to borrow £1,576 for the purchase of land in Bentinck-street and Craven-street as a site for the central station, and also for the sum of £18,424 for the purpose of constructing the station, for providing mains, distributing and other plant and materials for the execution of works, and for the payment of the costs and expense of the Birkenhead Electric Lighting Order, 1890. Alderman Deakin moved the confirmation of the minutes of the Finance Committee, and said the Council had recently sanctioned the purchase of land for the purpose of electric lighting, and the committee recommended that the necessary sum of £1,517 be borrowed. They had been in communication with Mr. Shoolbred, who had been their adviser, and he had informed them that to make the necessary arrangements it was usual for corporations and other bodies to ask power from the Local Government Board to obtain money for the whole purpose at once. Referring to his former estimates, he believed they would not be very greatly varied, and that £20,000 would cover the cost of the first installation. The Finance Committee had by no means hurried the matter forward; on the contrary, it had received the greatest deliberation. Several years had elapsed since the question was first considered, and it was satisfactory to know that in the intervening period valuable experiences of other places had been obtained, and the committee hoped the money would be remunerative. Mr. Gostenhofer seconded the motion, which was adopted.

Canterbury.—The Town Council have received the following communication from Mr. A. J. Lawson, the engineer and manager of the County of London and Brush Provincial Electric Lighting Company, Limited: "The question of the electric lighting of Canterbury has come before my Board on several occasions, and the Board have instructed me that provided two gentlemen of good financial position and influence in Canterbury or neighbourhood would consent to act as directors of the Canterbury Company, each investing £500 (the directors' qualifications under the articles of the association), and that a sum of not less than £6,000 and not more than £7,500 of the first issue of the shares be subscribed locally, we should be prepared to find twice the amount of the local subscriptions, and proceed with the work within the present year. My Board consider that unless local interest in the company be shown, both by subscriptions to the capital and promises of custom to the company when started, it would be undesirable to invest money in the undertaking. In order to ascertain the views of the citizens on the question, and to obtain the information mentioned above, we should esteem it a favour if the Mayor would agree to convene a meeting of the principal citizens at any convenient time within the next fortnight, when one of the directors of this company and myself would attend and explain fully the position of affairs, furnishing such information in our power as might be desired by the meeting" The Mayor is arranging for an interview.

Sheffield Electric Light and Power Company, Limited.—The report of the directors of this Company states that during the 12 months ended December 31, 1893, the Company's energies have been directed to the establishment of a system of underground mains, and to the construction of a new electric light station. The underground mains and station have now been completed, and were opened by the Mayor on March 17, 1894. The accounts of the Company for the past year have necessarily suffered by the interference with the production and supply of current, consequent upon the operations referred to, as well as the disastrous coal strike. The balance of profit for the year is £585 5s. 6½d., which the directors propose to carry forward to the current year. In order to provide capital for the extension of mains into new districts, and to defray the cost of new buildings, works, and machinery, which the development of the business and the increasing demand for current renders necessary, the Board recently resolved upon an issue of £25,000 4½ per cent. debentures and 6,000 ordinary shares; and they are glad to report that such issue was favourably received. Owing to the growth of the Company's business, and its probable development in the future, the directors propose to submit to the shareholders at a meeting which will be called within the next few weeks, an alteration in the Company's memorandum and articles of association with a view of making them more convenient and better adapted to the present status and requirements of the Company. Under the Company's articles of association one-third of the directors retire at the ensuing annual meeting, and accordingly Messrs. George Franklin and Joseph Gamble will retire, being eligible for re-election. The Company's auditors, Messrs. T. G. Shuttleworth and Son, also retire, but are eligible for re-election.

Fareham.—At the last monthly meeting of the Local Board the following letter was read from the electric lighting company: "Fareham, May 28. To the Fareham Local Board: Gentlemen,—I am instructed by the directors of this company to respectfully inform your Board that unless this company can obtain a larger amount of public and private support than has been hitherto accorded them, they do not feel justified in carrying on the business any longer. A considerable sum of money will be required to place the mains under ground, as per the conditions of our provisional order, and unless a larger amount of support could be obtained it would be useless to embark further capital in the business. We trust your Board and the public will give us the requisite additional support, and thereby render it unnecessary for us to advise the Board of Trade of our intention to abandon our provisional order. Should we feel compelled to abandon our provisional order, then the Board of Trade will give your Board notice under sections 65, 66, and 67 of the aforesaid orders, by which your Board will have the option of purchase within two months after the service of the said notice, the value being agreed or estimated in a manner directed by the Electric Lighting Act, 1888, section 2. Premising your Board does not desire to purchase under present conditions, and not wishing to take steps that might place both your Board and this company in a somewhat undesirable position, we would beg to make the following suggestions: the company are prepared to provide 10 arc lamps in lieu of the small lamps now used in the following streets—*i.e.*, one on Wallington Bridge, two in Trinity-street, two in School-road, one in Grove-road, two in Portland-street, and two in Hartlands-road or Quay-street—for an additional sum of £150 per annum for the remaining period of the lighting contract. I trust your Board will consider this proposal favourably, and therefore avoid the loss of a light which we believe is generally appreciated by all.—I am, gentlemen, your obedient servant, Arthur Blake, secretary." It was decided to hold a special meeting on the subject. At this meeting, which was held on Friday last, and after a long and angry discussion, Mr. Blake, on behalf of the company, withdrew his offer respecting additional lighting, and though asked repeatedly to renew the letter from the company, he positively declined, on the ground that after what had taken place he could not ask the shareholders and bondholders for more capital to put wires underground.

Lighting of Cardiff.—In view of the forthcoming inauguration of the supply of electric light, the *Western Mail* has been making

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investigations on the subject of the comparative cost of gas and electric lighting for the benefit of the inhabitants. As might be expected, the local paper "plumps for" the electric light. In the course of an article it states the town clerk of Bradford intimates that in that town the cost of fitting up premises for the electric light, including switches, is estimated at from 18s. to 23s. per incandescent lamp, exclusive of the service cable, which is laid on by the Corporation at a charge of actual cost only. Mr. W. T. M'Gowen, the town clerk, further states also that "the charge for electricity is 5d. per unit for lighting purposes, and 3½d. per unit for motive power. The price charged for gas is 2s. 3d. per 1,000 cubic feet, with discounts varying from 2½ to 12½ per cent. Both the gasworks and the electricity works are in the hands of the Corporation. It is hardly possible to compare the electric light with gaslight for illuminating purposes, because the advantage of the former over ths latter is so great. Mr. R. Hill-Dawe, the town clerk of Hull, gives the following statement by the electrical engineer of that borough: "There are two gas companies supplying two different districts of Hull, and the electric light mains are laid in about equal portions of the districts supplied by the two gas companies respectively. The rate in one district for gas is 2s. per 1,000 cubic feet, and in the other is 3s. per 1,000 cubic feet. The present rate for all current supplied in both of the districts is 7d. per Board of Trade unit for lighting purposes, and 5d. per Board of Trade unit for use for electric motors. The proportion which this price bears to the gas at 2s. per 1,000 cubic feet is about 2½ to 1, and at 3s. per 1,000 cubic feet is about 2 to 1. We are not in a position to say whether the consumption of gas has been affected to any great extent, as the Corporation are not the owners of the gasworks, but the electric light is being taken up very readily, and fresh applications are continuously coming in. We are, however, of opinion that the greater cost of the electric light in comparison with that of gas is but a small consideration in the light becoming generally adopted, as the main point with intending consumers is undoubtedly the original cost of the house installation, which in some cases means discarding valuable gas fittings and considerable alteration to premises. It is, however, not so difficult to say which is the more economical light, as the general destructive effects of gas on materials and decorations are entirely obviated by the use of the electric light."

Chester.—At the monthly meeting of the Town Council, held on Wednesday, in connection with the electric lighting question, Alderman H. T. Brown moved that the resolution of the Council of October 11 last, determining that the Hope-pole Paddock be the site for the proposed electric light generating station, be rescinded. He said the resolution was passed in consequence of pressure brought to bear upon that Council. The selection of the site was entirely made by the Electric Lighting Committee, and it was not chosen by the engineer (Dr. Hopkinson) who was called in to advise the Council. Dr. Hopkinson had reported in regard to the site, to which objection had been taken on account that the machinery of the station would cause vibration, that smoke would be caused, and the unsightly appearance which the buildings would present. Vibration was considered a matter which would be exceedingly detrimental to the cathedral, which was adjoining; but Dr. Hopkinson thought there would be no risk. If the works were permitted to be erected on the Hop-pole Paddock, the persons residing in the district would be at the mercy of those works. The Electric Lighting Committee had recently visited Oxford for the purpose of inspecting the system of electric lighting in vogue there, and he was under the impression that the members of that deputation had somewhat modified their views respecting the adoption of the Hop-pole Paddock. The dean and chapter had offered to purchase the site for the purpose of an open space for the benefit of the public, allowing the Corporation to retain any portion of the land abutting on the paddock for the improvement of Frodsham-street. Mr. G. A. Dickson seconded the motion. Mr. W. C. Deeley, on behalf of the Electric Lighting Committee, moved a direct negative, pointing out there was only a sentimental grievance, and expressing surprise at the continued objections put forth by Alderman Brown. He wished to say that every engineer who had been to Chester had selected the Hop-pole Paddock *par excellence* for the electric lighting installation station. If the Council had to purchase another site, it would cost some thousands of pounds. Councillor J. Jones (Boughton Ward) seconded the amendment. Councillor Churton remarked that the Council had already decided that the paddock should be used for the purpose of an electric light generating station. The committee which had been to Oxford had returned, he believed, very largely informed. Councillor B. C. Roberts believed that the committee at their last meeting were unanimously in favour of the Hop-pole Paddock not being wanted for the station, but that they would not recommend the Council to sell it to the dean and chapter. Councillor Churton considered it would be perfectly ridiculous to dispose of the paddock. After further discussion the motion was carried by 17 to 13.

Barnet.—The Local Board last week discussed the report of the Electric Lighting Committee. The report stated that the answers received by the clerk to the Board's circular, inviting agreements for the ratepayers to take the electric light, were read by them at their last meeting. It appeared that there were 315 houses in the district over £20 ratable value. Three hundred and fifteen circulars were delivered: 37 ratepayers were favourable to the light, but would not sign the agreement; 26 were undecided; no reply was received for 35; and 19 were not at home. The collector's report stated that a large number of the occupiers declined to have anything to do with electric lighting, on the ground that its adoption might involve the district in considerable expense and so increase the general district rate. Other ratepayers asked that the matter should be postponed until after the election of the District Council; they thought it should form one of the questions on which the election should be fought. Many of the ratepayers agreed as to the badness of gas and to its high price, but they stated that as they had already been put to considerable expense in providing gas fittings, they were not inclined to spend further sums in electric lighting appliances. It had been suggested by several ratepayers that the Board should fit up the houses with the necessary appliances and charge a rent. A letter was then read from the Brush Company offering to give further information. A letter was also read from Messrs. Crompton and Co. to Mr. Morse in reply to a letter addressed by that gentleman to the company. It was as follows: "In reply to yours of the 25th May, the time you give us is too short to say further to-day than that Mr. Albright and myself, as managing directors, are agreed that we should be quite prepared to recommend to our Board the acceptance of the general principle of undertaking for a period of years the risk of running, without any guarantee, the local authority finding the necessary capital. Of course there are many details of such arrangements as these which would require careful consideration, and we should be glad, if the Local Board of Barnet accept the general principle, to meet you, or any member of your committee, to discuss such details." The committee recommended that the Board accept the principle as set out in Messrs. Crompton's letter, and that negotiations be opened with a view to a scheme being submitted to the Board at a subsequent date. Mr. Walker moved, and Mr. Clarke seconded, the adoption of the report. After considerable discussion, however, the following amendment, proposed by Mr. Morse, and seconded by Mr. James, was carried: "That the report be not adopted, but that the Board are prepared to discuss the matter with Messrs. Crompton on the basis of the capital being found by the Board, but without finally accepting the principle that the capital be found by the Board, that being left open for consideration when all the details are before the Board."

Electric Lighting of Hampstead.—The Finance Committee of the London County Council reported on Tuesday as follows: We have considered the application from the Hampstead Vestry for sanction to the borrowing of a further sum of £25,000 for electric lighting purposes on the instalment system for 50 years. On December 5, 1893, we reported on a similar application, and as the Vestry then required to take up only £5,000 the loan was limited to that amount, and as it was for buildings only the repayment was spread over 30 years. The estimate of the Vestry, as then submitted and reported to the Council in detail, amounted to £19,000; but it is now stated that subsequent enquiry has shown that to be insufficient, and hence the present application for sanction to the borrowing of £25,000, in addition to the £5,000 advanced. The revised estimate is made up as follows: boilers and accessories, £5,090; engines and dynamos, £6,140; switchboards, £720; house connections, £300; mains, £4,830; arc lamp-posts, etc., £700; transformers, etc., £1,600; making good paving, £725; meters (100), £400; engineer's commission, £1,000; making a total of £21,505. The Council's engineer considers some of the prices excessive and the value of the works to be £19,647, which, divided in accordance with the probable life of the works, would be £7,893 for 30 years, £11,354 for 15 years, and £400 for five years. The estimate for the construction of the central supply station and offices, and chimney shaft, including clerk of works' salary and architect's commission, is £8,900, of which £8,400 may have a life of 30 years, and £500 15 years. The total amount, £28,547 (£19,647 and £8,900), if taken according to estimated life, would be £16,293 for 30 years, £11,854 for 15 years, and £400 for five years; but as the Vestry has already borrowed £5,000 for 30 years, the item of £16,293 would be proportionally reduced. The equated period of repayment for these reduced amounts works out at 22 years, and for the full amount (£28,547) at 23½ years. We reported very fully to the Council on February 13 last in connection with the St. Pancras case as to the period for which electric lighting loans should be sanctioned by the Council. We then informed the Council that the Local Government Board, after much deliberation and consultation with experts, fixed the period of 25 years for repayment of loans for electric lighting purposes borrowed under their sanction, and the Council after much discussion and consideration of the question in all its bearings adopted the view that 25 years was a proper period to fix for repayment. Although the equated period in the present instance is somewhat less, we think the merits of the case will be met by adopting the same period, especially having regard to the fact that there is no expenditure for land, but for which, if there had been, the full period would have been recommended; the sanction only of the Council being applied for to the raising of the money. We recommend—(*a*) that the sanction of the Council be given to the borrowing by the Vestry of Hampstead of the sum of £23,500 towards defraying the cost of an electric light installation in that parish, at a rate of interest not exceeding £3. 10s. per cent. per annum, and to be repaid by instalments of principal, or principal and interest combined, within a period of 25 years from the date of the loan; (*b*) that the seal of the Council be affixed to the order submitted with the report.

Monmouth.—The following communication from the assistant secretary of the Local Government Board was laid before the Town Council at a meeting last week: "I am directed by the Local Government Board to advert to your letter of the 10th inst. forwarding a copy of report by Messrs. Bramwell and Harris on the competitive schemes for the disposal of the sewage of the borough of Monmouth. When the Town Council have decided what scheme

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they will adopt, the Board should be furnished with plans of the works and with detailed estimates of their cost, with a copy of the resolution of the Town Council authorising the necessary application for a loan, and with information respecting the assessable value and existing debt for sanitary purposes of the borough. Suitable forms are enclosed." The Mayor remarked that some few days ago, anticipating that he would be asked how they stood with reference to their drainage and electric lighting scheme and Messrs. Bramwell and Harris's report in the matter, he asked the town clerk to write to Messrs. Bramwell and Harris asking if there would be anything ready for the Corporation meeting of that day. The following letter was received from that firm in reply: "We are obliged by your letter of yesterday, and, in reply, beg leave to say that we are afraid that we have very little information as yet to lay before the Council. We will endeavour, however, before Monday to show to you or to the Mayor a plan showing the amount of ground which would be required for the sewage station. The plan of the site at the Old Forge is in hand, but we must, before letting you have this, determine exactly what size buildings are required to contain the electric lighting machinery there. This we are giving our attention to, and we hope to let you have a plan of this probably some time next week. Before anything can be definitely arranged, however, it will be as well, as we have said, to obtain some sort of formal or informal agreement with the owner of the land to be used for the sewage farm. Until this is done nothing definite can be decided, and we gather from the Mayor's letter that the owners of the suggested sites will require to see the plans of the buildings proposed before they would say whether they would consent to 'sell' or 'let' or not." Since then the following letter has been addressed to the town clerk by Messrs. Bramwell and Harris: "I enclose you herein the duplicate of a letter which I have sent to the Mayor by this post; from this you will see that there are some drawings which it will be possible to bring before your Council at their meeting on Monday. I would much prefer, however, that this should not be done, but that the matter should stand over until it is more advanced. I hope in the course of next week to let you have the rough sketches of the buildings necessary for the electric light station if it is placed at the Old Forge." The Mayor pointed out that they could not move in the matter until they got the general report from the experts. They had been asked for a rough design by Mr. C. M. Crompton-Roberts, and a rough design was now to hand, and he formally moved now that it be sent to Mr. Crompton-Roberts, so that he could see their position in the matter. Mr. Morgan asked if any reply had been received from the Duke of Beaufort's agent. The Mayor answered in the negative. He thought it would be better for the town clerk to write and explain that they were waiting for such a communication in order to see their position in the matter. The town clerk was instructed accordingly.

PROVISIONAL PATENTS, 1894.

JUNE 4.

10798. **Improvements in the lighting, and in lamps used in coal-mines and the like by electricity.** Walter William McLauchlan, 14, Irwell-terrace, Lower Broughton, Manchester.

10803. **Improved means for waterproofing fabrics, paper, and the like, and for insulating electrical conductors.** William Thomson and Alfred Ebenezer Mavor, 66, Barton-arcade, Manchester.

10823. **A new or improved process for the extraction of aluminium from certain clays by electrolysis.** Alfred Francis Bilderbeck Gomess, 24A, Alfred-place West, South Kensington, London.

10851. **Improvements in electric railway signals.** Henry Harris Lake, 45, Southampton-buildings, Chancery-lane, London. (Frank Beattie, United States.) (Complete specification.)

10853. **Improvements in electrical accumulators for storage batteries.** James Yate Johnson, 47, Lincoln's-inn-fields, London. (La Société L'Accumulateur Fulmen, France.) (Complete specification.)

JUNE 5.

10917. **Improvements in electric safety fuses or cut-outs.** Sebastian Ziani de Ferranti, Charterhouse-square, London.

10952. **Improvements in electrodes.** Carl Hoepfner, 45, Southampton-buildings, Chancery-lane, London.

JUNE 6.

10967. **Improvements in electrical switches.** John Henry Tucker, 10, Ryland-street, Birmingham.

10978. **Improvements in electric measuring instruments.** Walter Thomas Goolden and Sydney Evershed, 1, Woodfield-road, Harrow-road, London.

11022. **Improvements in alternate-current rectifiers and apparatus connected therewith.** Sebastian Ziani de Ferranti, Charterhouse-square, London.

JUNE 7.

11069. **Improvements relating to the transmission of signals through submarine telegraph cables.** Alexander Muirhead, 124, Chancery-lane, London.

11100. **Improvements in electric dental motor apparatus.** Francis Napier Denison, 4, South-street, Finsbury, London. (Complete specification.)

11059. **Methods of and apparatus for varying the frequency and number of phases in a polyphase electric current and for converting alternating electric currents into continuous currents, and for other purposes.** Henry Augustus Rowland, 55, Chancery-lane, London.

JUNE 8.

11136. **Improvements in the regulation of electric distribution systems.** Reginald Wood, 28, Southampton-buildings, Chancery-lane, London.

11160. **Improvements in apparatus for starting electric motors.** Henry Willock Ravenshaw and Messrs. Easton, Anderson, and Goolden, Limited, 1, Queen Victoria street, London.

JUNE 9.

11211. **Improvements in railway electrical signalling apparatus.** Walter Grimes, 323, High Holborn, London.

11219. **Incandescent electric lamps and sockets therefor.** Charles Albert Hussey, 1, Queen Victoria-street, London. (Complete specification.)

11225. **Improvements in and relating to arc electric lamps.** Henry Revis and Hugo Hirst, 73, St. Stephen's-road, Upton Park, London.

11241. **An improved electric lamp.** Frederick Richard Boardman, 433, Strand, London.

SPECIFICATIONS PUBLISHED.

1893.

2696. **Telautographs.** Newton. (Gray.) (Second edition.)
9296. **Electrolysis of salt.** Craney. (Second edition.)
10129. **Electrical conductor.** Edmunds.
10218. **Distribution of electricity, etc.** Wood.
10788. **Generation of electricity.** Parsons.
13672 **Transmitting telegraphic, etc., signals.** Brown and King.
19542. **Electrolytical decomposition of salt solutions.** Kellner. (Second edition.)
23913. **Dissociating soluble salts by electrolysis.** Haddan. (Blackmore) (Second edition)

1894.

5971. **Using electric light for photography.** Adamson.
6491. **Converting electric currents.** Pitt. (Blondel and others.)
7215. **Electric printing telegraph apparatus.** Magnin.
7617. **Thermo-electric generators.** Cox.

COMPANIES' STOCK AND SHARE LIST.

Name.	Paid.	Price Wednesday.
Birmingham Electric Supply Company	5	5½-5¾
Bournemouth Electric Company	—	—
Brighton and Hove Company Original	100	210-215
Brush Company, Ordinary	5	2¾-3
—— Nom. Cum, 6 per cent. Pref.	2	2¼-2½
—— 4½ Debenture Stock	100	106-111
Charing Cross and Strand	5	4½-5½
Chatham and Rochester	—	—
Chelsea Electricity Company	—	—
City of London, Ordinary	10	12-13
—— 6 per cent. Cumulative Pref.	10	13½-14
—— 5 per cent. Debenture Stock	75	84-86
City and South London Railway, Consolidated Ordinary	100	36-38
—— Debenture Stock	100	119-121
—— 5 per cent. Pref. Shares	10	12-12½
Crompton and Co., 7 per cent. Cum. Pref. Shares	5	3-3½
—— 5 per cent. First Mortgage Debentures—1-400 of £100 and A, 1-200 of £50	100	96-100
Elmore's French Company	2	1-1¼
Electric Construction, Limited	2	1¼-1½
—— 7 per cent. Cumulative Pref.	2	1½-1¾
Elmore's Copper Depositing	2	1½-1¾
Electricity Supply Company for Spain	5	—
Elmore's Wire Company	2	1¼-1½
Fowler-Waring Cables	5	1-1¼
W. T. Henley's Telegraph Works, Ordinary	10	6½-7½
House-to-House Company	5	1-1¼
India Rubber and Gutta Percha Works	10	23-24
—— 4½ per cent. Debentures	100	103-105
International Okonite, Ordinary	10	1-2
Kensington and Knightsbridge	5	4½-5½
Liverpool Electric Supply, Ordinary	5	6½-6¾
—— Pref.	4½	5½-6½
Liverpool Overhead Railway	10	8½-9
—— Pref.	10	12½-13½
—— 4 per cent. Mortgage Debentures of £100	100	113-114
London Electric	5	1-1¼
Metropolitan Electric Supply	10	8½-9
—— 5 per cent. Reg. Debentures, 1-10,000 in Bonds of £10, £20, and £40	—	107-110
National Telephone, Ordinary	5	4½-5½
—— 6 per cent. Cum. First Pref.	10	15-18
—— 6 per cent. Cum. Second Pref.	10	14½-15½
—— 5 per cent. Nom. Cum. Third Pref.	5	5½-6½
—— 4½ per cent. Deb. Stock	—	115-117
Notting Hill Company	10	4½-5½
Oriental and Electric Company, £1 shares	1	1-1¼
Southampton Electric Company	—	—
St. James's and Pall Mall, Ordinary	5	7-7½
—— 7 per cent. Pref.	5	8½-9½
Swan United	2½	1-1½
Telegraph Construction and Maintenance	12	39-41
—— 5 per cent. Bonds	100	104-107
Westminster Electric Supply, Ordinary	5	9½-10½
Yorkshire House-to-House	4½	4½-5½

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NOTES.

Electric Lighting in Hanover.—The street arc lighting is to be extended.

German Installations.—There are now 8,000 electric light installations in Germany.

Rotthalmunster.—The whole of the street-lighting in this town will soon be electric.

Aberdeen.—The electric light is to be fitted up in the police offices at an expenditure of £250.

St. Thomas's Hospital.—The library of this hospital on the Thames-embankment is lighted by electricity.

Aigle.—There is a movement on foot to construct an electric tramway between Aigle, in the canton of Vaud, and Leysin.

Leek.—The electric light question is, it appears, as far off as ever. Probably this is due to the leaky state of some of the pockets.

Electro-Chemistry.—Chairs of electro-chemistry are to be founded in the Polytechnic Academies of Berlin, Hanover, and Aix-la-Chapelle.

Argentine Republic.—Messrs. Schuckert and Co., of Nuremberg, have received the order to erect a central electric light station at Santiago, in the Argentine Republic.

Wynau.—On the 1st prox. work will be commenced on the central electric light station, for which Messrs. Siemens and Halske have acquired water power. About 4,000 h.p. is available.

Gross-Kanisza.—We have already referred to the electric lighting central station in this Hungarian town. We now learn that the public lighting was to be inaugurated last week.

City and Waterloo Electric Railway. — The works of the new electric railway between the City and Waterloo Station have been commenced by the contractors, Messrs. John Mowlem and Co.

Bunzlau Telephones.—The long-distance telephone system which extended from Bunzlau to Liegnitz, has now been further extended to Berlin. The charge made is 1s. for three minutes' conversation.

Frankfort Accumulator Works.—These works on the Pollak system have been converted into a limited liability company. Mr. Charles Pollak is manager and Mr. Hermann Massenbach assistant manager.

Accumulator Traction.—The management of the tramway company in Hagen, Westphalia, intend to introduce accumulator traction on the section of their line between Markt, Körnerstrasse, and Kückelhausen.

Electromotors.—The use of electric motors in connection with electric light installations is being largely extended in Leipsic, especially in the printing and bookbinding trades, which form the staple industries of the town.

Electric Lighting in Leipsic.—Apart from the central station which is waited for, a number of large firms are introducing private installations not only for lighting purposes, but also for transmission of power.

Ascona. — The works in connection with the electric lighting of this Swiss town are almost completed. The water power of the old Maygetti sawmill is employed. The project has been carried out by Mr. Moja Francesco.

Tottonham.— The Tottenham Local Board have received notice from the Tottenham and Edmonton Electric Light and Power Company of intention to apply for a provisional order to light part of the district by electricity.

Chinese Telegraphs.—Dr. Morrison, who has arrived at Bhamo from Shanghai, reports that the Superintendent of Chinese Telegraphs has received orders from the Chinese Government to extend the telegraph line from Momein to Burma.

An Electric Fleet.—It is reported that the ornamental waters in the parks of the city of Boston are to be equipped with a fleet of about 250 boats, including a number of electric launches, which are to be charged from the Edison circuits.

Electric Lighting at Cahors.—The Municipality have taken action against the gas company to compel them to supply electric light. In the event of the refusal of the company to do so, the town will give a concession from the month of March next.

Electric Tramway at Erfurt.—Official trials have recently been made of the electric tramway, which has been erected on the Thomson-Houston system by the Union Electricity Company of Berlin. A part of the system is now open for public traffic.

Harbour-Lighting at Mayence.—The harbour has hitherto been lighted partially by electricity, four arc lamps and 180 incandescent lamps being employed. The Municipality have now decided to extend the installation to 20 arc lamps and 500 incandescent lamps.

Marmande.—A committee of the Municipal Council has been formed to consider a proposition of the Franco-Belgium Gas Company, who propose to introduce the electric light, and do other work, in consideration of their concession being extended by 30 years.

Indian Telegraph Revenue.—The revenue of the Indian Telegraph Department during 1893-94 shows an increase of four lakhs of rupees on private messages as compared with the previous year, and a decrease of one lakh in expenditure on State telegrams.

Steinau-on-the-Oder.—The streets here have been lighted by petroleum, but the question of lighting them by electricity is under consideration. A concession has already been granted for private lighting, orders from 40 persons for 500 lamps having already been received.

West Metropolitan Tramways.—A Board of Trade enquiry is to be held in respect of these tramways, the proposed sale of which last week was fruitless. Possibly if the Lineff system had been carried out as originally intended, the present position of affairs would not have obtained.

Electric Lighting of Bordeaux.—Attention has been drawn, at a sitting of the Municipal Council, to the delay in introducing the electric light into the town. It was stated that a project was being worked out by a specialist in Paris, who would shortly report to the Council on the subject.

Berlin and Munich Telephone.—Arrangements are being made for the establishment of telephonic communication between Berlin, Leipzig, Nuremberg, and Munich. There will also be connected with the system the towns of Augsburg, Bamberg, Bayreuth, Erlangen, Fürth, Regensburg, and Würtzburg.

The Government and Telephony.—As nothing has yet been seen of the agreement with the telephone company which the Postmaster-General promised to lay on the table as far back as April 30 last, Mr. Jackson intends to ask Mr. Arnold Morley when the publication of the document may be expected.

Electrical Navigation.—An advertiser in a daily paper desires a capitalist to finance a new system of electrical navigation. He says that the method "has been

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enthusiastically received by influential marine authorities." It is a pity that their enthusiasm was so lukewarm as to induce them not to finance the system.

Laying of New Mains.—The House-to-House Electric Light Supply Company intend to lay mains and construct street boxes in Warwick-gardens, and in Bolton-gardens, Wetherby-road. The Westminster Electric Supply Corporation are about to lay mains on both sides of Chester-terrace, between South Eaton-place and Eaton-terrace.

Plauen (Saxony).—An electric tramway now about to be constructed necessitates the widening of a bridge, which the Town Council have authorised to be carried out. Plauen needs electric traction. It is no joke being there in the winter time, notwithstanding the so-called pleasures of sledge driving and the unintelligible local German dialect.

Shoreditch.—The Shoreditch Vestry have at last agreed to purchase the Pitfield site for an electric lighting station. The price to be given is £33,500. The whole scheme is estimated to cost over £100,000. The Vestry have decided to petition the Board of Trade for an extension of 18 months on the provisional order in which to complete the scheme.

Electric Tramway in Kiew.—About two years ago the General Electricity Company, of Berlin, constructed an electric tramway at Kiew, which was the first in Russia. It has now been decided to extend electric traction to three other routes. There are to be 32 self-contained cars, each capable, in case of need, of drawing a trailer. Overhead conductors are employed.

West Bromwich Tramways.—The object of the Tramways Orders Confirmation (No. 2) Bill is to confirm provisional orders made by the Board of Trade, including an order authorising the construction of tramways in West Bromwich and a portion of Handsworth, in the county of Stafford, and for other purposes. Electrical engineers should look after this enterprise.

Electric Traction on Snowdon.—A public meeting of the ratepayers of Llanberis has been held to consider the advisability of taking measures to make the place more attractive to visitors. It was reported at the meeting that a movement was on foot to construct an electric railway to the top of Snowdon, the name of Mr. Assheton Smith being associated with the scheme.

Neversink Mountain Electric Railway.—We have received a copy of a reprint from the *Electrical World* describing the Neversink Mountain electric road, together with results of tests. The reprint, which is well illustrated, comprises several articles published in that journal from the pens of Messrs. Hermann S. Hering and Wm. J. Aldrich, of Johns Hopkins University.

The Leeds Tramways.—The Highways Committee of the Leeds Corporation had under consideration, on Tuesday, the estimates submitted to the Tramways Committee with reference to the letting of the tramways, and the matter now stands over for the sub-committee to make further investigations, and to visit Newcastle and Edinburgh, where the cable system is in operation.

An Advertising Dodge.—We note, according to the *Financial Times* of Wednesday, that the *Cable Gazette* is being made the means, through the Eastern Extension Telegraph Company, of disseminating news about the plague in Hong-Kong. Evidently the *Financial Times* did not understand that the object of this was to secure a free advertisement for the electrical contemporary in question.

Electric Lighting in Letzwyl.—This Swiss village is to receive the electric light. The community have to pay nothing for the water power, and will supply private lamps at 12s. 10d. per 16-c.p. lamp per year. The cost of the installation, exclusive of the lamp itself, comes to 16s. per lamp. Of the 60 public electric lighting stations in Switzerland none has been able to supply private consumers at so cheap a rate.

Dear Granny.—Dear old grandmother — we beg pardon, the *Daily News*—discovered on Tuesday that a dinner cooked by electricity was given at the Cannon-street Hotel on the previous Friday. Dear granny recently became stouter—in fact, increased her number of pages, but notwithstanding this, she, like the *Times*, does not object to give information that has already appeared days previously in other papers.

Electrically-Heated Cloth-Presses.—An electric system of imparting a gloss to textiles has been patented at the works of Mr. J. Sarfert in Reichenbach, Saxony. The method consists in heating the press plates by the electric current, which is conveyed into the plates by leading-in wires. An illustrated description of the system is given by Prof. E. Müller, of Hanover, in *Dingler's Polytechnisches Journal* of June 15.

Yacht-Lighting.—Messrs. D. and W. Henderson, of Partick, have built the largest steam-yacht ever launched on the Clyde for Mr. Arthur E. Wood, of Newboldlevel, near Rugby. She is lighted throughout with electricity, and is fitted with a very powerful search-light, placed in the fore end of the deckhouse, on a movable platform. The electric installation has been carried out by Lord Claude Hamilton and Co., Limited.

"Medical Electrical Institute."—We regret to notice that the creditors of the "Medical Battery" Company, Limited, have resolved to form a new company, under the title of the "Medical Electrical Institute," to acquire and carry on the old undertaking. If the new company intends to conduct the business on the same lines as those of the old concern, we hope that the present scheme of reconstruction will fall through.

Electricity in Dundee.—At a meeting of the Works Committee of the Dundee Gas Committee held on Tuesday, the question of providing additional plant for the electrical station was discussed, and it was resolved to ask the engineers, Messrs. Urquhart and Small, to prepare a report for the consideration of the Commission. A satisfactory report was submitted by Messrs. Urquhart and Small on the works for the installation as taken over from the contractors.

Electric Cloak Pegs.—To avoid thefts in cloakrooms, Mr. Maurice Salomon is reported to have invented a special peg on which a coat or a hat may be hung. The peg is connected with a small electric battery and bell. When the weight of the coat or hat is on the peg it cuts off the current of electricity and the bell remains silent. Immediately the article of apparel is taken off the peg the bell rings, calling the attention of the cloakroom attendant to the fact of the removal.

Ventilation of Tunnels.—A report has been called for by the Board of Trade from the Metropolitan Railway Company, showing the efforts that have been made by the company to mitigate the effect of the poisonous fumes that are given off in the tunnels in certain sections of their system. The company would be wise in overcoming this difficulty in some manner or other. If they are not yet disposed to adopt electric locomotives, they might erect more ventilating-shafts, with fans driven by electric motors.

Electric Supply in Every City Street.—The City of London Electric Lighting Company notify that they are now in a position to supply electricity for all purposes in every street and lane within the City of London, and in

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St. Saviour's district, Southwark. Consumers who undertake to use 75 per cent. of their current between the hours of 10 p.m. and 6 a.m. are granted a special rate of 4d. per Board of Trade unit, and this rate is also charged for all current used for heating, cooking, and motive-power purposes.

New Electrical Engineering Works.—According to a German contemporary, a syndicate of capitalists propose to erect at Bayreuth a large works for the manufacture of electrical plant, and more particularly of dynamos. The members of the syndicate have been in the town with two engineers to look for a suitable site. They propose to utilise the water power of the Maine for part of the power required at the works. It is also proposed to enter into negotiatiations with the Municipality for the erection of a central station.

Commercial Cable Company's Cable.—The steamship "Faraday" has picked up the Irish shore end of the Commercial Cable Company's third cable between Ireland and Nova Scotia, which was laid in April, and having spliced on the main, or deep-sea section, is now paying out westward. At noon on Wednesday, the "Faraday" had paid out 175.6 knots from the eastern splice, making a total of 316.7 knots from Waterville, Ireland, the position being lat. 51 44 N., long. 18 17 W. The ship was then passing over the deepest water, and all was going well.

Transmission of Power.—An interesting installation has been carried out by the Oerlikon Works at Mr. C. Scheuffele's paperworks at Oberlenningen, Wurtemberg. The River Lauter furnishes power to the extent of 250 h.p., of which 135 h.p. is made use of for lighting and power purposes. Three-phase alternating-current motors at the generating station supply current at 1,000 volts to the factory, where it is transformed and distributed to the lamps and to various motors. At the works 123 effective horse-power is obtained, so that the loss in transmission is less than 10 per cent.

The British Association.—The *Transactions* of this association for 1893, embodying the report of the Nottingham meeting, have just been published in a volume of over 1,000 pages. It contains the addresses of the president and the presidents of sections, the reports of the many committees that work during the year, and a record of the papers read at the meeting by title, abstract, or text. One paper printed in full is that by Mr. W. W. Beaumont on the automatic balance of reciprocating mechanism, which is accompanied by illustrative figures. The reports include those on standards for use in electrical measurements, and on electrolysis and electro-chemistry.

Electrical Manufacture of Carborundum.—Some months ago the Franklin Institute, Philadelphia, awarded the John Scott legacy premium and medal to Mr. Edward G. Acheson for his discovery of a new artificial abrasive material, called carborundum. In the June issue of the *Journal* of the Franklin Institute the official report is printed with illustrations. The method of manufacture consists in subjecting mixtures of carbon with silica or silicious materials and a flux to an extremely high temperature in electrical furnaces. Carborundum is used for grinding and polishing metals, glass, and precious stones.

Northern Society of Electrical Engineers.—Mr. J. Darney, the hon. secretary of this society, of 4, Palatine-buildings, Hunt's Bank, Manchester, announces that the members will, on Saturday, the 23rd inst., pay a visit to the Liverpool Overhead Railway generating station and the Oldham-place central station of the Liverpool Electric Supply Company. A saloon carriage will be provided on the train leaving the Central Station, Manchester, at 1.30 p.m. Arrangements are being made for an excursion to the Antwerp Exhibition in July. Upwards of 20 members have already signified their intention of joining the party, and Mr. Darney will be pleased to hear from others who are disposed to accompany the party.

High-Pressure Direct-Current Transmission.—With reference to the article on this subject in our issue of May 25, and the comments of Mr. O. Görling on Mr. Schultz's proposal, which appeared in our "Notes" on the 8th inst.—in which the former stated that Messrs. Schuckert and Co. had previously carried out installations of the same character—Mr. Schultz now replies. He states that he has no desire to dispute the claim made on behalf of Messrs. Schuckert, but it would not be permissible to draw deductions therefrom, as he knows of a series installation on this system which has existed for longer—namely, that carried out at Solothurn by Mr. C. E. L. Brown on behalf of the Oerlikon Works. Claims for priority are consequently superfluous.

Direct-Reading Measuring Instruments.—As was briefly recorded by our correspondent in his report last week of the meeting at Leipzig of the Union of German Electrical Engineers, Dr. Th. Bruger read a paper on the subject of direct-reading measuring instruments. He pointed out that while at first physical measuring instruments were of service in electrical work, the progress of electricity resulted in new electrical instruments which were of use in physics. The main point in electrical measuring instruments now was to obtain the desired result quickly and direct without calculations or circumstantial manipulations. The instruments which the author described were those made by Messrs. Hartmann and Braun, of Bockenheim.

Personal.—The statement made by our correspondent in our last issue in regard to Mr. G. Kapp's appointment in Germany is now confirmed by the *Pall Mall Gazette*, which says: "England is losing a well-known and talented electrical engineer in the person of Mr. Gisbert Kapp, who has signed an agreement with the Union of German Electrical Engineers (Verband Deutscher Elecktrotechniker) as general secretary of the union, which has just guaranteed him an annual remuneration of £1,000." The *Indian Engineer* hears that Mr. R. Jamieson Browne, A.M.I.E.E., has proceeded to Afghanistan to superintend the erection of an electrical plant for the Ameer. The private address of Mr. Albion T. Snell, M.I.E.E., from to-day (the 22nd inst.) is South View, Brondesbury-road, N.W.

Laws of Galvanic Polarisation and Electrolysis. In an article on this subject by Mr. O. Wiedeburg, the author sought to give a consistent exposition of the phenomena of galvanic polarisation on the following fundamental assumptions. The ions are driven by the active E.M.F. towards the two electrodes, where they collect and generate new breaks in the potential, which, acting against the original E.M.F., regulate the current according to Ohm's law. All the ions that reach the electrodes, however, are not electrically active, but only a small proportion of them, the rest being neutralised, losing their ionic character, and contributing nothing to the sudden difference of potential. There is a limit to the gathering of the ions at the electrodes, and the relative amount which collects at any instant is smaller the nearer the amount already collected is to the limit, being proportional to the difference between the limiting and actual values at the instant considered.

Electrolysis of Gas and Water Pipes.—A committee was appointed some time ago by the Western Gas Association of the United States to investigate the question of electrolysis caused by street railway return circuits.

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The conclusions of the committee are summarised as follows: "1. Electrolysis from the grounded currents of electric roads is rapidly injuring gas and water pipes, and it is admitted by street railway people that the injury does proceed from their operations. 2. Complete relief from its action cannot be reached by any device applicable by those injured, but is attainable by certain changes in the electric railways. 3. The gas and water interest should unite in demands for remedial measures which shall secure the adoption of systems undoubtedly effective, and which will thereby avoid a revival of the question a few years hence. 4. Pending the discussion or completion of the relieving systems, the pipes should be protected at the exposed points, at which the policy of increasing the resistance by insulation should be followed rather than that of increasing the conductivity by wiring."

Electric Tramway at Lemberg.—In our last issue we mentioned that part of this line had been opened for traffic. The following particulars have now reached us. In Lemberg, which is the chief town of Galicia, the different sections of the electric tramway amount to a total of about five miles, of which about 3½ miles are now in operation. The gradients of the line are unfavourable, often amounting to 4 and 5 per cent., while at one point is reached 6·75. The curves are also sharp. Phœnix rails are employed for the track. The overhead conductors are carried on cross-wires, which are, according to the character of the surroundings, supported by ornamental iron posts, by ordinary wooden posts, or from walls. The current has an E.M.F. of 500 volts, the return circuit being through the rails, which have copper connections at the joints. There are to be 16 self-contained cars, of which one half is now in operation. The motors are of 25 h.p. Chain gearing connects the motors with the axles. There are two compound steam-engines at the generating station, each of 200 effective horse-power, and each driving direct a Siemens and Halske dynamo.

Damages for Electrical Shock.—In March last, while two men were taking a constitutional in Innsbruck, they discovered a telephone wire hanging down to the ground, when one of them picked it up and promptly yelled for assistance. His friend came to the rescue, knocked the wire out of his hand with a stick, and received a shock which rendered him unconscious. On recovering, he found that the picker up of unconsidered trifles was dead. A court of enquiry has now been held, at which three of the officials of the local electric lighting company were charged with culpable negligence. It appears that they had been warned several times that telephone wires above their conductors were broken, but no attention had been paid to the matter. The telephone wire in question had fallen across the conductor, resulting in the accident. One of the officials has been sentenced to one month's imprisonment, the second to four months' imprisonment, and the third has been discharged. In addition, an indemnity of 100 florins has to be paid to the injured man. Nothing has been awarded to the relatives of the dead man. It therefore appears that in Innsbruck it is less expensive to kill a man than simply to knock him down.

Electrical Conductivity of Gases.—In the *Zeit. Physikal. Chem.*, Mr. F. Braun gives the result of a number of different cases investigated as follows: (1) Compound gases at the moment of formation—The only cases studied were mixtures of (1) nitric oxide and air; (2) chlorine and hydrogen, which were caused to unite by the influence of heat or diffused daylight. A Leyden jar battery of about 4,000 volts E.M.F. was employed. No conduction was observable. (2) Gases during the time of explosion—A mixture of carbonic oxide and oxygen was employed, and a current from seven to twenty small Grove cells was employed; in this case there appeared to be undoubted conduction through the exploding gas. (3) Gases heated to high temperatures—The gases were heated in porcelain tubes to about 1,000deg. to 1,200deg., and the current used was that from a Leclanché cell. Ammonium chloride and cadmium iodide conducted well; ammonia, iodine, and hydrogen chloride conducted, as did to a less extent hydrogen iodide, hydrogen bromide, and probably mercuric oxide. No conduction was observed in the cases of carbonic anhydride, water, and nitric peroxide. The paper closes with a short discussion of the electric charges of flames, which the author considers to be due to a separation of positive and negative ions. The results in general confirm the experiments of De Hemptinne.

Lighting at Bournemouth. — On Tuesday Mr. F. H. Tulloch, M.I.C.E., an inspector of the Local Government Board, held an enquiry at the Municipal Offices into the application of the Bournemouth Corporation to borrow £4,000 for the purposes of electric lighting of the pier and gardens. The Council was represented by Mr. J. Druitt, jun. (town clerk), and Mr. F. W. Lacey (borough surveyor). There was no opposition, and the only members of the public present were the secretary and engineer of the local electric light company. Mr. Druitt, stating the object of the application, said that the Corporation had already erected engines in the pleasure grounds for the purposes of pumping salt water, and now wished to utilise the spare power for the purpose of lighting the pier and gardens by electricity. They had a license to do so from the Board of Trade, extending over seven years, for much wider powers than those they were now seeking. Mr. Lacey said that the two engines in the gardens indicated 80 h.p. each, but for the purpose of pumping they only used one engine for about 12 hours a day. They would require 51 h.p. for the lighting of the gardens, and 45 h.p. for the pier on ordinary occasions, and an extra 20 h.p. on special occasions. The Council had also other property in the Winter Gardens which it was suggested should be lit by the Corporation. He thought they would have sufficient power to work both the electric light and the pumping, and would be able to so arrange matters that it would not be necessary to have the engines working for the two purposes together. Subsequently the inspector inspected the engines and the places proposed to be illuminated.

New Gas Tramcar.—It is proposed to make experiments with a gas-motor car on the single line of tramway connecting Thornton Heath with Croydon, and it is claimed by Mr. B. W. Wallace, Mr. H. P. Holt, and others interested in the enterprise, that gas will be found far less expensive than any other means of traction. A trial trip made on Tuesday demonstrated that the car can travel at any speed between four miles and eight miles an hour, and that it can ascend steep gradients and turn sharp curves with ease. The gas is drawn from the mains and compressed by a pump into a steel cylinder or receiver, at a pressure of 150lb. Thence it is passed into three smaller cylinders concealed in the bed of the car and under the seats. The gas-cylinders in the car can be recharged in two minutes, and it is calculated that the cost of the gas consumed, at 3s. per 1,000ft., is 1d. per mile run. The motor is of the Otto type, and is specially constructed for tramway work. It has a slow and a quick speed, but the latter cannot exceed eight miles an hour—the maximum speed allowed by the Board of Trade. The ignition of the charge in the motor cylinders is effected by electricity, and the cylinders exhaust into a condenser so as to avoid smell causing a nuisance. The charging station is at the depôt

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of the Croydon and Thornton Heath Tramways Company at Thornton Heath, where an 8-h.p. Otto gas-engine drives the compressor. In Germany, several similar cars are in daily operation. Among those present at the trial were Mr. W. Carruthers-Wain; Mr. J. G. B. Elliott, secretary of the Tramways Institute; Mr. F. O. Driscoll, M.P.; and Mr. P. Holyoake, secretary of the Traction Syndicate, Limited, which has acquired the patent rights in the invention, which is of German origin.

Banquet Cooked by Electricity.—To get custom for current by day as well as by night is a point aimed at by all supply companies. So far there has not been much progress made in this country in the use of motors supplied with current from lighting mains nor in the use of current for heating and cooking purposes. In order to give proof positive of the capabilities of cooking by electricity the City of London Electric Lighting Company, Limited, on Friday evening last gave a banquet thus cooked at the Cannon-street Hotel, showing their confidence in the excellence of their cooking arrangements by inviting the Lord Mayor, who, in his official capacity, is, of course, an excellent judge of what constitutes a good dinner. The hotel has its own electric light installation, but for cooking this dinner a cable was led from behind the hotel from the mains of the City Company. The dinner was prepared in Crompton electrical ovens, which are furnished with four switches so as to control the heating of either the top or the bottom or the sides independently, or the whole of the oven, an arrangement which is exceedingly serviceable. The other appliances included electrical hot-plates, frying-pans, etc. The dinner proved most satisfactory, and in the course of the evening Sir David Salomons, who occupied the chair, proposed the toast of "Success to Electricity," in which he stated that the company were pioneers in electric cookery. They had the satisfaction of knowing that the food had not been spoiled by the taste of gas or the products of combustion. The company charged 8d. per unit for current for lighting purposes, which was dearer than at the West-end, but then they had fewer working days. For cooking purposes they would charge half—namely, 4d. per unit. That evening the number of units used was 60 for ovens capable of providing for 120 guests, the cost working out to ·2d. per course for each guest. Prof. Silvanus Thompson and Dr. Ernest Hart responded to the toast. It may be noted that, appropriately enough in connection with this banquet, the engineer to the company is Mr. Cook.

Royal Meteorological Society.—The closing meeting of this society for the session was held on Wednesday at the Institution of Civil Engineers, Mr. R. Inwards, F.R.A.S., president, in the chair. Mr. R. H. Scott, F.R.S., read a paper on "Fogs Reported with Strong Winds during the Fifteen Years 1876 to 1890, in the British Isles." Mr. R. H. Curtis, F.R.Met.Soc., read a paper on "Some Characteristic Features of Gales and Strong Winds." After calling attention to the unsatisfactory state of anemometry, and after describing the "bridled" anemometer at Holyhead, Mr. Curtis stated that the greatest force of an individual gust which he had met with was registered in December, 1891, and amounted to a rate of 111 miles per hour, which with the old factor would be equivalent to a rate of about 160 miles per hour. Gusts at a rate from 90 to 100 miles per hour have many times been recorded, but the usual limit for gusts may be taken to equal about 80 miles per hour, which on the old scale would be equivalent to about 120 miles per hour. Gales and strong winds differ in character very much; and as the result of a prolonged study of their general features, as recorded by the bridled anemometer, the author has been able to group them into three general classes. He then described those gales which are essentially squally in character, in which the gusts constitute the main feature of the gale. In an average gale the ordinary gusts follow each other at intervals of about 10 to 20 seconds, while the extreme gusts occur at the rate of about one per minute. Another class of gales is those in which the velocity of the wind is tolerably steady. In the third class are gales which appear to be made up of two series of rapidly succeeding squalls—the one series at a conparative low rate of velocity, the other at a much higher one, the wind force shifting rapidly and very frequently from one series to the other. Mr. Curtis also stated that on looking carefully over the anemometer records he had not unfrequently found very distinctly marked a prolonged pulsation in the wind force, which recurs again and again with more or less regularity of perhaps 20 minutes or half an hour in some cases, and in others at longer intervals of about an hour, more or less.

The Stockholm Central Station.—The *Journal* of the Institution of Electrical Engineers contains a description from a German contemporary of this central station. It states the station was begun in October, 1890, and the trial runs took place in July, 1892, the works being opened on September 1 of that year. The buildings have accommodation for the completed plant, but the engine-room and accumulator-house are only calculated for half the amount. The boilers, dynamos and engines, and accumulators are at present capable of supplying 10,000 30-watt lamps. In the boiler-house there are fitted two Babcock and Wilcox water-tube boilers of a heating surface of 1,870 square feet, and room is provided for five more of the same size. Every boiler has 96 tubes of 102mm. diameter and about 16ft. long, divided into 12 groups of eight tubes. The boilers all feed into a common steam service pipe, having a branch to every steam-engine. The boilers are fed by Worthington duplex pumps, which take the feed water from a reservoir below, which receives the condensation water. The fuel used is coke from the town gasworks. The steaming tests gave for every kilogramme of coke (deducting ash) 7·17 kilogrammes of steam, containing 2 per cent. of moisture. The two steam-engines now working are made by W. Lindberg's Company, in Stockholm, and are marine triple-expansion condensing engines. Their normal output is 250 h.p., and can be raised to 310 h.p. as a maximum. The cylinders are 371mm., 594mm., and 965mm. in diameter respectively. At the trials these engines gave a consumption of 5·91 kilogrammes of steam per indicated horse-power at the normal load, and 6·16 kilogrammes at the maximum output. Each engine is directly coupled to a dynamo, the inside-pole machine of Siemens and Halske. These dynamos have six poles, and develop 340 volts and 670 amperes at 100 revolutions. At the trials the output was 330 volts × 686 amperes for 361·4 i.h.p. (German horse-power = 736 watts). They were run for 24 hours, and the rise of temperature of the armature was 35deg. C., and that of the field magnet coils 21deg. The engine-room has room for another similar dynamo of 500 h.p., and there is ground for enlargement. The batteries consist of 280 Hagen accumulator cells, arranged as two double batteries, and the three-wire capacity of the whole is 2,500 ampere-hours. The regulating arrangements are as usual, and the regulation is done by hand. The feeders are connected to the omnibus bars by automatic resistance regulators. The cables are armoured and lead-covered, laid direct in the ground in general, but in iron pipes where requiring protection. The main house fuses are so arranged that the house can be put on either side of the middle wire as required.

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PHYSICAL UNITS.

BY MAGNUS MACLEAN, M.A., F.R.S.E.

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(Continued from page 693.)

§ 17. The symbols to be used for the three fundamental units are: for length, [L]; for mass, [M]; and for time, [T]. The symbols L, M, T, without brackets, will be used to denote the number of such units in the quantity to be expressed. We have now to determine the relations of the other physical units to these chosen fundamental units, and to examine the laws according to which the derived units vary when the fundamental units are changed from one system to the other system. Every physical quantity essentially consists of two factors: (1) the fundamental unit employed, and (2) a numeric* which expresses the number of times the fundamental unit is to be taken to make up the physical quantity considered. Thus the numeric is the ratio of the physical quantity considered to the unit chosen as fundamental unit. In symbols, if [Q] is the fundamental unit, and Q the physical quantity considered, we have $Q = n\,[Q]$, where n is a numeric as above defined, and may be integral or fractional. Thus in the expression 56 metres, 56 is the numeric n, and metres is the denominational part represented by [Q]. If n is unity, the quantity expressed is the unit.

§ 18. Geometrical quantities are independent of the units of mass and time, and kinematical quantities are independent of the unit of mass, and these may be first considered. Kinematics may be defined as the geometry of motion. It differs from kinetics in not considering (1) the masses of the bodies moved, (2) the forces causing the motion, and (3) any mutual forces called into action between the bodies moved, on account of the motion.

Unit *area* or surface, is that of a square which has unit length for edge. Hence its dimensional formula is $[S] = [L^2]$.

Unit *volume* is that of a cube which has unit length for edge. Hence its dimensional formula is $[V] = [L^3]$.

Unit *plane angle*, called a radian, is the angle subtended at the centre of a circle by an arc equal in length to the radius. Its dimensional formula is therefore length by length $= [L^0]$.

Unit *solid angle* is the angle subtended at the centre of a sphere of unit radius, by unit spherical surface of that sphere. Generally the measure of a solid or conical angle is obtained by dividing the area cut off by the cone from a sphere whose centre is at the vertex of the cone, by the square of the radius of the sphere. Its dimensional formula is therefore $[L^2]/[L^2] = [L^0]$.

Curvature is the angle turned through by the tangent, per unit of length of the curve. Its dimensional formula is therefore $1/[L] = [L^{-1}]$.

Tortuosity is the angle turned through by the osculating plane, per unit of length of the curve. Its dimensional formula is therefore $[L^{-1}]$.

[For an analogy between lines and surfaces as regards curvature, for definitions of *curvatura integra*, *average curvature*, *specific curvature*, see Thomson and Tait "Natural Philosophy," second edition, § 136 and § 138, p. 105 and p. 109.]

§ 19. *Velocity* is rate of change of position in space, and a body is said to have unit velocity when, if the motion be uniform, it passes over unit space in unit time. Its dimensional formula is therefore $[v] = [L]/[T] = [L\,T^{-1}]$. Thirty miles an hour = 44ft. per second.

The dimensional formula for angular velocity is $[\omega] = [T^{-1}]$.

Acceleration is rate of change of velocity, and its dimensional formula is $[a]$ or $[\dot{v}] = [v]/[T] = [L\,T^{-2}]$.

Similarly, angular acceleration $[\dot{\omega}] = [T^{-2}]$.

§ 20. *Momentum* of a body is the product of its mass into its velocity, and its dimensional formula is therefore $[M\,v] = [M\,L\,T^{-1}]$.

* Fourier, "Theorie de la Chaleur," § 160, p. 157; English translation, by Alex. Freeman, M.A., p. 126. Thomson's "Arithmetic," ed. lxxii., p. 4. In this connection a reading of a paper, by A. Lodge, in *Nature*, July 19, 1888, p. 281, on "The Multiplication and Division of Concrete Quantities," is recommended.

Force, by Newton's second law of motion, is proportional to the time rate of change of momentum.

$$F \propto , Ma = \text{constant} \times M\,a.$$

If we define unit force as that force which will produce unit acceleration in unit mass, the constant in the equation will be unity. This is what is done, so that unit force is that force which, acting on unit mass for unit time, will produce in it unit velocity. In the British system, unit force is called a poundal. A poundal is that force which, acting on 1lb. for one second, generates in it a velocity of 1ft. per second. In the metric system, unit force is called a dyne. A dyne is that force which, acting on one gramme for one second, generates in it a velocity of 1cm. per second. If gravity be allowed to act on a mass for unit time, the velocity acquired is g units. Hence the force of gravity is g times the unit of force as above defined.

One pound weight = g poundals.
One gramme weight = g dynes.

§ 21. The force of gravity varies from place to place on the earth's surface. There are two main reasons why the force of gravity at sea-level should be different at different parts of the earth's surface—(1) the shape of the earth, and (2) the rotation of the earth. The earth is not an exact sphere, but more like an oblate spheroid. Its polar diameter is approximately 27 miles less than its equatorial diameter. Hence by Newton's universal law of attraction, stated in § 11, the force of gravity at the equator is less than at either pole. Centrifugal force, however, gives the predominant cause of the variation of gravity. At the equator gravity and centrifugal force act in opposite directions, and at other places on the earth's surface the angle between the direction of gravity and the direction of centrifugal force is equal to the latitude of the place of observation, and their resultant is to be found by the parallelogram of forces.

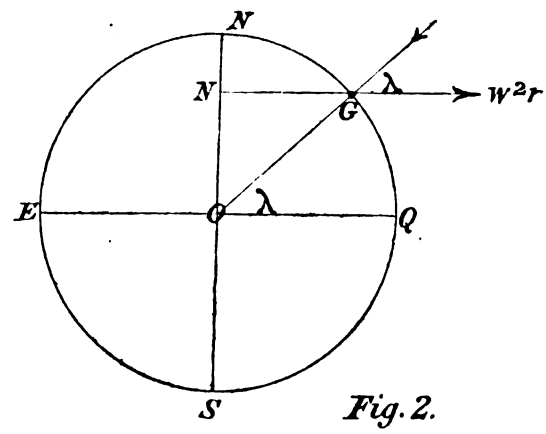

Fig. 2.

§ 22. Let Fig. 2 represent a diametral section of the earth, supposed here to be spherical. E Q is an equatorial diameter, and N S the polar diameter. G is a place on the surface whose latitude is λ. The centrifugal force acting on unit mass, which revolves in a circle of radius r, with angular velocity ω, is equal to $\omega^2 r$. The centrifugal force acting on unit mass at G is along N G and equal to $\omega^2 r \cdot \cos\lambda$, where r = O Q. This may be resolved into two components—one acting vertically against gravity, and one acting horizontally towards the equator. The two components are respectively $\omega^2 r \cdot \cos^2\lambda$, and $\omega^2 r \cdot \cos\lambda \cdot \sin\lambda$. At the equator λ is zero, so that the centrifugal force at the equator per unit mass is $\omega^2 r$. Using the two systems of fundamental units, the centrifugal force at the equator per gramme

$$= (2\pi/86{,}400)^2 \times 637 \times 10^6 \text{ dynes},$$
$$= 3{\cdot}37 \text{ dynes},$$

and per pound $= (2\pi/86{,}400)^2 \times 21 \times 10^6$ poundals,
$= {\cdot}0111$ poundal.

This is approximately 1/289 of the force of gravity at the equator, so that gravity at the equator is diminished by 1/289 of itself by centrifugal force. The two causes together diminish it by $\frac{1}{195}$ or about ½ per cent. At sea-level* on the earth's surface the force of gravity is

* See footnote § 7.

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very approximately given by the following formula:

$$g = 32{\cdot}088\ (1 + {\cdot}00513 \sin^2 \lambda) \text{ poundals},$$
$$= 978\ (1 + {\cdot}00513 \sin^2 \lambda) \text{ dynes},$$

where λ is the latitude of the place of observation.

The dimensional expression for force is therefore

$$[F] = [M\,a] = [M\,.\,v/T] = [M\,L\,T^{-2}].$$

§ 23. The measure of *work* done is the product of the force acting into the distance through which it acts. This assumes that the displacement takes place in the direction in which the force acts. If it does not, the work done is measured by the product of the displacement into the effective component of the force in the direction of the displacement. The dimensional expression for work is therefore

$$[W] = [F\,.\,L] = [M\,L^2\,T^{-2}].$$

The units for force and work are for clearness put into the following tabular form:

—		Gravitation unit.	Kinetic unit.
Force	British system	Pound weight	Poundal
	Metric system	Gramme weight ...	Dyne
Work	British system	Foot-pound	Foot-poundal
	Metric system	Centimetre-gramme	Centimetre-dyne or erg

In practical electricity a unit of work, called a *joule*, is employed, and is equivalent to 10^7 ergs.

§ 24. *Energy* of a body is the capacity it has for doing work. The gain or loss in the energy of a body is equivalent to the work done upon the body, or to the work done by the body. This is true whether the gain or loss of energy be due to change of configuration or position, or to change of motion. Or, in the usual nomenclature, the work done by the body, or done on the body, is a measure of its loss or gain of energy, whether that energy be what is generally called *potential energy* or *kinetic energy*.

Hence the dimensional formula for energy is the same as that for work:

$$[E] = [M\,L^2\,T^{-2}].$$

The relations between the British and metric units of force and work are:

One pound weight = 453·6 grammes weight.
= 445,052 dynes.
One poundal = 14·1 grammes weight.
= 13,825 dynes.
One foot-pound = 13,825 centimetre-grammes.
= $13{\cdot}56 \times 10^6$ ergs.
= thirteen and a half million ergs.
One foot-poundal = 429·5 centimetre-grammes.
= 421,386 ergs.

(To be continued.)

THE NEWCASTLE TRAMWAY REPORT.

BY FRANK B. LEA.

The *Electrical Engineer* published the other week (see issue of June 8, page 677) the full report of Mr. W. G. Laws, M.I.C.E., city engineer of Newcastle-upon-Tyne, respecting the tramway system of that place, as ordered by the Tramways Committee of the Corporation, and the details therein set forth will provide some useful texts for a brief discourse upon the subject of electric traction.

In the first place, however, it is not desired by the writer to pose in any way as a hostile critic of the views held and expressed by Mr. Laws; the main conclusions to which this gentleman comes are undoubtedly the wisest and safest possible, both generally and as regards the special conditions which govern the Newcastle tramway system.

The engineer, it is stated, was asked by the committee to report upon three different systems of traction—viz., horses, underground electric conduit, and cable or wire rope. In the exercise of their discretion, the Tramways Committee decided beforehand against the use of both overhead electric conductors and accumulators. Probably no one unconnected with battery manufacture (nor for that matter many of those who have to deal with the practical working of accumulators) would raise much of a voice in protest against excluding battery cars from consideration: the steep grades which rule on most of the Newcastle routes would alone serve to show the inadvisability—not to say absurdity—of doubling, or even trebling the weight of cars. But when the committee shuts the door at the very outset upon electric traction by means of overhead conductor wires, one cannot help feeling that they show somewhat ill-advised haste in such an action. Of course they will have considered the question in some form or another, though whether this consideration can possibly have been adequate may well be doubted. The chief reasons urged against overhead wires are strictly of an æsthetic nature; and Newcastle itself—though a town of tolerably clean and interesting streets—can hardly be thought so beautiful that overhead wires would impair the glamour of its highways, or prevent their proper and safe use by the public. Mr. Laws—and every other engineer of experience—would doubtless admit that an overhead conductor system is the cheapest to construct, so far as capital outlay is concerned; and if he were to consult Mr. Alfred Dickinson, of the South Staffordshire Tramways, he would also find out that the cost of operating such a line is less even than when the cable system of traction is employed. Figures, of course, may be twisted into any shape or direction; but if one accepts those put forward by advocates of each system, there is a saving of 1d. per car mile effected by employing electricity. The average cost of cable traction is stated to be 4d. per car mile. Mr. Dickinson vouches for it that the cost on his electric line does not exceed 3d., under no very exceptional circumstances either.

It is, therefore, to be somewhat regretted that the Newcastle Tramways Committee did not at least seek for a report from their engineer which should embrace a system of electric traction admittedly the cheapest to instal, and, in addition, the cheapest to operate, so far as we may judge from the lines already at work in this country—*e.g.*, the South Staffordshire Tramway, and to a large extent the Liverpool Overhead Railway. Questions absolutely depending upon financial points—that is, to put it concretely—the problems of giving quick, cheap transit on an economical basis, can hardly be settled by paying most consideration to æsthetic arguments against something new, such as an overhead wire equipment. The pocket of John Bull is usually the court of last appeal, and it ought to be so in this case.

Had Mr. Laws been instructed to report also upon the overhead conductor system, he would doubtless have made full enquiry respecting this from other engineers, such as Messrs. T. Parker, J. Hesketh, Kapp, E. Hopkinson, etc., who have made a special study of electric traction, and are fully able from experience to say what it can do and what it cannot. Indeed, to judge from some of Mr. Laws's criticisms upon electric traction in his report as it stands, he would have been well advised to do this in any case. The gentleman who seems to be his authority as regards electrical conduit tramways—Mr. W. N. Colam—is an engineer of no mean position, and he has studied, as the writer knows, the Budapest lines on the spot. The details which he thus gives, and the conclusions at which he arrives concerning this system are accurate and fair; indeed for one who, like Mr. Colam, is so professedly an advocate of cable tramways, the description appears to be remarkably unbiassed. The same cannot altogether be said, however, when electric traction is discussed in the report in more general terms. Mr. Laws brings forward as a serious obstacle to the adoption of electric working, the "difficulty of applying any electric system to towns where there are hills to surmount"! Surely, Mr. Laws does not mean to imply that there is an inherent weakness in electric traction which prevents it from overcoming the effects of gravity in the same way that other motive powers can do!

Accepting his figures for the moment, it may very well be that a car which would consume 10 e.h.p. on the level would require 28 e.h.p. to carry it up a grade of 1 in 20, and 36 e.h.p. on a grade of 1 in 10, the speeds being respectively reduced 40 and 60 per cent.; but Mr. Laws

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cannot get over the fact that a given weight of car and passengers will require just the same power to take it up a given grade at a given speed whether the motive power be electricity, an endless wire rope, steam locomotive, or horses. Why, then, does he bring it forward as an objection to electric working that a car takes more power to run up a hill than on the level? True, there are, on a cable line, as a rule, some descending cars whose momentum under the action of gravity tends, of course, to balance the extra requirements of power for those going up: but the same thing may be said of an electric line. Motors going down grade can, when properly arranged, serve quite well as generators to help the big machines at the supply station in supplying current to those going up; the fact that so far electrical engineers have not attained quite such a pitch of refinement in their work does not alter the principle in any way, and when it becomes necessary to make the extra saving of a small fraction of a penny per horse-power hour, they will soon obtain as efficient a rate of working as with the cable on this point.

Mr. Laws does not give the weights of cars or passengers, etc., on which are based the figures above mentioned, and it is therefore difficult to verify them. What any ordinary electrical engineer would say, however, is that the power required for working a car on a heavy grade increases in amount, as pointed out by Mr. Laws, when the car travels at *constant speed*. To reduce the velocity in anything like the proportion he names ought surely to imply that the output of horse-power on the axle is kept constant. This may be effected with a considerable degree of nicety by electrical adjustments of the car motors, field coils, and armatures; or, again, whilst reducing the speed and the output, the efficiency of the motors may be kept up to the normal degree. As a matter of fact, the only disadvantages under which electric cars in general may be said to labour—as compared with cable cars—consist of the extra car weight due to the motors and gear, necessitating thereby a little extra power in taking the car up hill, and second, the lack of sufficient refinement in electrical engineers to avail themselves of the power now lost in the descending cars.

So far, by the way, there seem to be few or no statistics of a reliable nature, such as station indicator diagrams and car dynamometer records, which would actually prove that the momentum of descending cars on a cable road nearly balances the retarding effect of those going up. Of course, theoretically, one would admit it at once, but theory and practice do not always exactly fit one another.

It is to be regretted that Mr. Laws should have declared himself quite so strongly on this point against electric traction, for there was no need of much discussion about the matter. Electrical engineers are ready enough to admit the splendid results given on cable lines along certain routes, and at present a hilly district requiring frequent services of cars will in nine cases out of ten offer more scope for profitable use of a cable system than any electrical method as yet known. Newcastle is just such a place; the street, whilst by no means beautiful, are not very wide, and an overhead conductor system might conceivably have offered difficulties, though not insuperable, on that score; the cable will do all that is required—will do it well, and cheaply. Other towns, however, need not necessarily conclude that the same conditions will apply in their case; and if their engineers should be called upon to report as to the most advisable system of mechanical traction to adopt, it is to be hoped that they will be given a free hand to go into the whole question, and discuss it properly and fully.

ELECTRICAL SHOP EQUIPMENT.*

BY HOWARD L. INGERSOLL.

Shops, factories, and mills at the present time are, for the most part, well equipped with modern appliances in steam-driven machinery. In a few printing and lithographing establishments, where the necessity of cleanliness is combated by the tendency of belting to fling dust about the room, line shafting has been replaced by a motor in each room. This reduces belting and shafting by a half, and the improvement is quite marked.

The complicated fixtures—shafts, countershafts, pulleys, hangers, and belts—entailed by the common means of transmitting power, present at the same time favourable and seriously objectionable features. In their favour, it may be said that they are well known; improved by all good appliances obtainable; and, in cases where very small work is done, are the best known ways of transmission.

Offsetting this, we have the first cost of material and placing, which is considerable; they always require a great amount of attention and repair, occupy much valuable space, furnish easy and multiple chances for accident and loss of life, and, furthermore, tend to stir the latent particles of dust and dirt, cause them to become an ingredient in the air breathed by workmen and a deposit on all articles within reach. These are objections—serious ones, too—which, in cases of shops supplied with medium and heavy machinery, outweigh the favourable qualities which have made our present equipment the rule.

Considering, first, the betterment of a shop already constructed and running, let us see how changes may be applied. This establishment has its own power plant—boilers, engine, etc. Let the same power plant remain to serve in the new order. With the addition of a generating plant of one or more dynamos, there will be the basis for an electrically-driven manufactory. From the generating plant the current is taken to the separate departments by ordinary means. It is distributed through the department

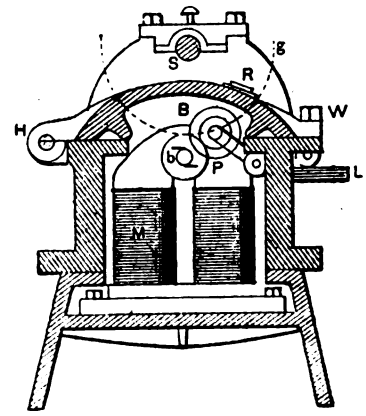

FIG. 1.

by means of a conductor, which may be placed in a similar position relative to the machinery that the line shaft occupied. The hinging point of the change comes here. Each large and independent machine contains a motor in some out-of-the-way part of its frame, which, through gearing, furnishes the driving power.

As to the application of the motor to these various tools, these plans are the result of dynamometer tests with different ones, relative to determining the power required for each under the different conditions appearing in every-day practice. The designs are the outcome of attempting to locate the motor in a protected, yet convenient spot, in the frame of the machine. A complete illustration of this is not necessary, and we will only specify in one or two cases.

First, let us take a lathe. The one experimented with was a 16in. lathe, and various tests were made with different materials, and cut up to the maximum. It was found that under full load (with belt just holding) the power necessary averaged 0·2489 h.p. This includes friction of adjunctory parts used on lathes. Therefore, with a 1-h.p. motor, wound with resistance in series with field, and the range of speed adjusted at 800 to 1,600 revolutions per minute, the requisite change of speed and a considerable excess of power would be realised. The operator has a switch in circuit with the above-mentioned resistance, which enables the regulation (now made by cones) and the reversing to be done. Thus, the overhanging shipper is done away with.

The motor, M (Fig. 1), is located under the headstock, which hinges on lugs, H, at the back of the bed, which

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allows of lifting the headstock to examine the motor. It is the only means of access to the motor, as the cabinet at the head end is a closed casting. The motor rests on a shelf cast on the cabinet, and ribbed for rigidity. The headstock drops on V-ways and the wrist-bolts, W, at the front clamp it solidly in place.

The motor shaft and armature are represented by *b* in Fig. 1, and the pinion, P, is of such a ratio to *g* (gear between bearings on spindle) as will give proper velocity ratio for highest speed. R is the operator's regulating switch on top of headstock. B is the back gear, operated by a stop-lever at L. The back gear is thrown in by offsetting *g*. This gear, *g*, has an extended hub on one side, through which is a stop or pin fitting into a hole in the lathe spindle. To set *g* for back gear, it is moved from the face-plate into the position above the pinion on the back gear arm; then the gear *d* on B, which is above P and gears with it, and the pinion *a* on B are thrown into gear by L. See Fig. 2.

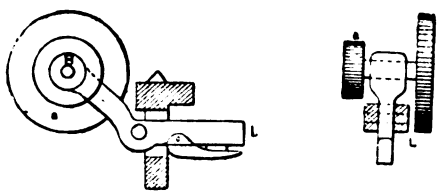

FIG. 2.

This makes a compact arrangement, the motor being entirely hidden and at the same time readily accessible. The screw cut, feed, and other details are applied in a similar manner to ordinary lathes.

The planer offers a ready location for the motor underneath the bed, on a cast shelf, enclosed, and free from dirt. The difficulty to be overcome is the reverse and quick return. The solution to this is quite simple. It necessitates a friction-clutch between two gears on the planer spindle. These gears, Fig. 3, are of different size (*g* and G). P is the pinion on the motor, Fig. 3, and is so arranged as to drive an idler, I, gearing with the quick return gear, *g*, on the spindle of the planer. Another pinion at a distance = *d* from P drives the feed, or forward gear, G, direct.

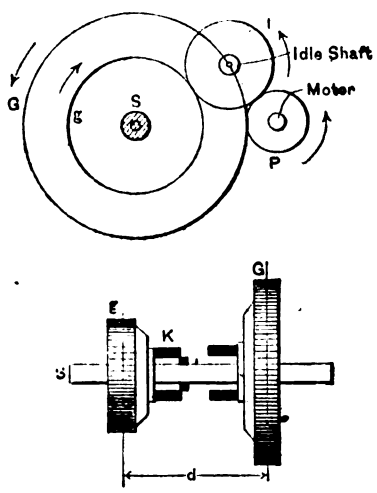

FIG. 3.

Thus we obtain a slow cut, and by having *g* the requisite ratio to P, we can have any quick turn desirable. The clutch, K, is operated by a shifter on the planer table, such as is ordinarily used for shifting belts. The motor is always rotating in the same direction, and, furthermore, the friction-clutch between *g* and G throws the load on gradually. If desired, a switchboard can be used to give changes of speed. The coupling to a shaper may be made in a similar manner, with the exception that the clutch is unnecessary, the Whitworth quick return being entirely sufficient. The motor would be placed in the bottom of the casting, and geared to the quick return of the common shaper.

For a drill press, the connections would be similar to a lathe, the motor either boxed at the base, and the stepped cones and belt used to connect power with spindle, or placed on a shelf beside the spindle and geared to it.

For driving power for small machines—grinding machines and the like, a few of which are necessary in any shop—belting would probably be indispensable. The cost of these machines, supplied with an independent motor, would be so much compared with their earning capacity that it would be useless to put independent driving mechanism in each. Therefore, it would seem that the surplus power of some large machine might serve the few small tools. The lathe, or other large tool, would be connected to the others by belting, placed along walls of the room so as to be out of the way. The motor in this lathe could be run, whether it were used to propel the gear on the lathe or not. Thus it would furnish an ever-ready power for the small sub-tools. The small amount of belting and necessary adjuncts to consummate this would not be a factor.

The arguments for and against present methods in equipment have been given above, together with the advantages to be derived by a change. The only valid argument against this projected method is the cost of these specially-built machines. However, when once the manufacture is undertaken, and the machinery given a fair trial, its advantage will be proven clearly. It may be said here that the writer knows of two large firms, builders of machine tools and their accessories, who are experimenting along these same lines. One of them has a line of tools on the market.

To return to the question of economy. The extra cost of the motor would be small compared with the cost of additional labour required to attend shafting and repair belts. Further, the work of one man will be more productive when the system is tried. Besides this, nothing has been said of the cost of keeping a shop in a cleanly condition, which would be much decreased by avoiding belting. In the case of an old shop, while the utility would be unquestionable, yet the advantage of a change might be uncertain, owing to the expense. But where a new equipment and new establishment are planned, economy and all other considerations point to the fact that the first additional outlay would be well placed.

The noisy and dirty workroom will be changed to a place of quiet and orderliness, and be a matter of pride to the proprietor who has had the wisdom and foresight to keep pace with the tireless march of progress, and the workers in these places will have better nerves, senses, and lungs.

PRACTICAL NOTES ON DYNAMO CALCULATION.—III.

BY ALFRED E. WIENER.*

(Continued from page 703.)

In the last section of this article, Chapter 3, on "Conductor Velocity," was omitted. It is given below. Also the headings of Tables IV. and V. were interchanged—that is, the table under the heading "Table IV.—Practical Field Densities in English Measure," should have been placed under the heading for Table V., and *vice versâ*. Formula (5) should read as follows:

$$S = \frac{d'_a \times \pi}{12} \times \frac{N}{60}, \quad \ldots \quad (5)$$

In formula (6) the second equality sign was misplaced; it should be:

$$d'_a = \frac{12 \times 60}{\pi} \times \frac{S}{N} = 230 \times \frac{S}{N} \quad \ldots \quad (6)$$

3. *Conductor Velocity.*—Since it is cheapest to increase the E.M.F. of a dynamo by raising its speed, it will be best economy to run a dynamo at as high a conductor velocity as practically as possible. The cutting speed of an armature is limited mechanically as well as electrically; friction in the bearings, strain in the revolving parts due to centrifugal force, and heating of the armature, caused by hysteresis and eddy currents in the iron, play an important part in determining the proper conductor velocity. Furthermore, if the number of revolutions of the armature is fixed,

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either by its mechanical limit, or by the speed of the engine in case of a steam dynamo, or otherwise, then the above mechanical and electrical limitations alone are not sufficient for choosing the cutting speed; for too high a velocity, for instance, permissible from all other considerations, would excessively increase the diameter of the armature, and consequently would bring the size of the whole machine entirely out of proportion to its output.

TABLE III.—Mean Conductor Velocities.

Capacity in kilowatts.	Conductor velocity, in feet per second.—Belt-driven dynamos.—Drum armatures.	Belt-driven dynamos.—Ring armatures.	Direct-driven dynamo.
·1	25	50	—
·25	30	55	—
·5	32	60	—
1	35	65	—
2·5	40	70	25
5	45	75	26
10	50	80	28
25	50	80	30
50	50	85	32
100	50	85	35
200	50	88	40
300	50	90	42
400	—	92	44
600	—	95	45
800	—	95	45
1,000	—	95	45
1,500	—	100	45
2,000	—	100	45

In modern high-speed (belt-driven) dynamos the value of S for drum armatures varies from 25ft. to 50ft. per second, and for ring armatures, which offer a better ventilation, and are much lighter than drum armatures of the same diameter, ranges between 50ft. and 100ft. per second. In slow-speed (direct-driven) machines, velocities from 25ft. to 50ft. per second are employed.

In the average values of S for various classes and sizes of dynamos are compiled.

8. *Dimensioning of Toothed and Perforated Armatures.*—Armatures with toothed and with perforated core discs, which have been much used in recent years, offer the following advantages over smooth armatures: (1) excellent means for driving the conductors; (2) mechanical protection of the winding, especially in cores with tangentially projecting teeth, and in perforated bodies; (3) lessening of the resistance of the magnetic circuit, and therefore saving in exciting power; and (4) prevention of eddy currents in the conductors. Their disadvantages are: (1) increased cost of manufacture; (2) greater difficulty of insulating the winding from the core; (3) eddy currents set up by the teeth in the polar faces; (4) additional heat generated in the iron projections by hysteresis; and (5) leakage of lines of force through the armature core.

The latter disadvantage, however, is cancelled by the advantage of reducing, by lessening the magnetic resistance, the necessary exciting power in about the same degree as the leakage would otherwise increase it. The amount of this core leakage depends upon the relative sizes of the slots and the teeth, and, if the armature is otherwise properly dimensioned, will vary within the following limits:

TABLE XI.—Core Leakage in Toothed and Perforated Armatures.

Ratio of width of slots to their pitch on outer circumference. $\frac{n' \times s}{d''a \times \pi}$	Factor of armature leakage—Toothed armatures—Straight teeth.	Projecting teeth.	Perforated armatures.
0·4	1·40 to 1·35	1·55 to 1·50	—
·45	1·35 to 1·30	1·50 to 1·45	—
·5	1·30 to 1·25	1·45 to 1·40	1·50 to 1·45
·55	1·25 to 1·20	1·40 to 1·35	1·45 to 1·40
·6	1·20 to 1·15	1·35 to 1·30	1·40 to 1·30
·65	—	—	1·35 to 1·30
·7	—	—	1·30 to 1·25

On account of this core leakage, toothed and perforated armatures are to be designed for lower field densities than smooth ones; for values of practical field densities for straight-tooth armatures of various sizes see columns 4, 5, 10, and 11 of the previous Tables IV. and V. respectively, and for corresponding values for projecting tooth –, and for perforated cores, columns 5, 7, 12, and 13 of the same tables.

(*a*) *Toothed Armatures.*—The mean winding diameter, d'_a, of a toothed armature being determined by means of formula (6), its core diameter, or diameter at bottom of slots, d_a, Fig. 1, is obtained by deducting from d'_a the height of the winding space, or in this case, the depth of the slots, h_a, averages for which are given in the fourth column of Table XV., Chapter 9. The outside diameter of the armature, d''_a, over the teeth is obtained by adding h_a, from Table XV., to d'_a, from formula (6).

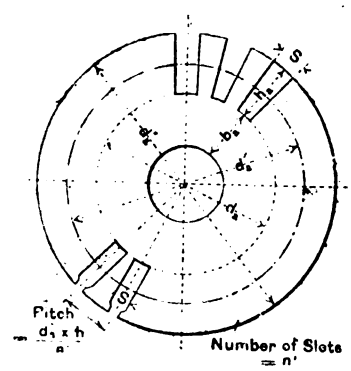

FIG. 1.

The number of the slots, n', depends upon the size of the armature. Practice has shown that better results are obtained from deep and narrow slots than from shallow and wide ones, and in consequence a large number of slots is preferable to a small one. The following are good practical limits:

TABLE XII.—Number of Slots in Toothed Armatures.

Diameter of armature, in inches. $d''a$.	Number of slots. n'.	Diameter of armature, in inches. $d''a$.	Number of slots. n'.
5	30 to 50	50	150 to 200
10	40 to 70	100	200 to 300
20	60 to 100	150	250 to 350
30	100 to 150	200	300 to 400

As to the width of the slots, its relation to that of the teeth is governed by the following considerations: On account of the disadvantage of the teeth creating eddy currents in the pole-pieces, their width ought to be small compared with that of the slots; in order to reduce the hysteresis loss in the teeth, and the heat caused by the same, to a minimum, the mass of the teeth should be small, and their area perpendicular to the flow of the lines, hence their width, large; for the sake of effectively reducing the magnetic resistance of the circuit the teeth ought to be as wide as possible; and in order to prevent an excessive core leakage, finally, a small width of the teeth should be chosen. Summing up all these conditions, a good practical rule seems to be to make the width of the slots

$$s = \frac{d''_a \times \pi}{2 \times n'}, \quad \ldots\ldots \quad (7)$$

that is to say, to make the width of the slots equal to half their pitch on the outer circumference; for the special case of a straight-tooth core, then, the width of the slots is equal to the top width of the teeth.

Applying this rule to armatures of various sizes, the writer has calculated the following table, giving dimensions of toothed armatures:

TABLE XIII.—Dimensions of Toothed Armatures.

Diameter of armature, in inches d''_a.	Dimensions of slots—Depth, in inches h_a.	Width, in inches s.	Ratio of depth to width. $h_a : s$.	Number of slots $n' = \frac{d''_a \times \pi}{s \times s}$	Core diameter, in inches. $d_a = d''_a - 2h_a$	Width at bottom of tooth, in inches. $\frac{d_a \times \pi}{n'} - s$
5	5/8	1/8	5·00	31	3¾	·125
6	½	17/64	2·83	36	4½	·128
8	⅜	9/32	3·11	45	6¼	·136
10	⅜	19/64	3·37	53	8	·178
12	7/16	5/16	3·60	60	9⅛	·198
15	½	21/64	3·81	72	12½	·218
18	9/16	11/32	4	82	15¾	·241
21	⅝	3/8	4	88	18	·268
25	11/16	13/32	4	97	21⅜	·299
30	¾	7/16	4	108	27½	·362
40	13/16	15/32	4	134	36¾	·383
50	⅞	1/2	4	157	46	·422
60	15/16	17/32	4	178	55¾	·454
70	15/16	9/16	4	196	65½	·487
80	1 1/16	19/32	4	212	75¾	·528
90	1 1/16	5/8	4	226	85	·557
100	1 1/8	11/16	4	230	94½	·602
125	1	5/8	4	262	119	·678
150	1 1/8	7/8	4	270	143	·791
200	1	1	4	314	192	·920

(*b*) *Perforated Armatures.*—The same considerations that prevailed in determining the number and the width of the

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slots in toothed armatures are also decisive for the dimensioning of perforated cores. The number of perforations, for this reason, can be taken in the same limits as the number of slots for toothed cores. See Table XII. In case of round holes, Fig. 2, the thickness of the iron between two adjacent perforations should be taken between 0·5 and 0·75 times the diameter of the hole.

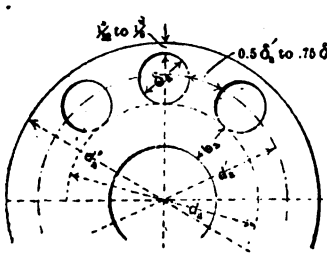

FIG. 2.

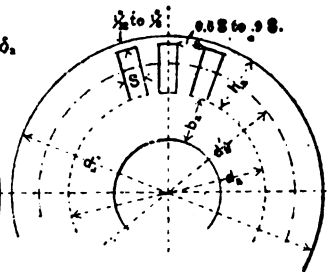

FIG. 3.

For rectangular holes, Fig. 3, the thickness of the iron between them is to be taken somewhat greater than for round holes—namely, from 0·6 to 0·9 times the width of the channel.

The distance of the holes from the outer periphery is to be made as small as possible, and may vary between $\frac{1}{32}$in. and $\frac{1}{8}$in., according to the size of the armature.

9. *Length of Armature Core.*—The number of wires that can be placed in one layer around the armature circumference and the depth of the winding space determine the total number of conductors on the armature, and the latter, together with the length of active wire, gives the length of the armature core.

(*a*) *Number of Wires per Layer.*—For smooth armatures the number of wires per layer is obtained in dividing the available core circumference by the thickness of the insulated armature wire. If the whole circumference is to be filled by the winding, then

$$o = \frac{1{,}000 \times d_a \times \pi}{\delta'_a} \quad . \quad . \quad . \quad (8)$$

where o = number of armature wires per layer;
d_a = diameter of armature core in inches;
δ'_a = width of *insulated* armature conductor in mils. (See Chapter 10.)

In case the winding is to consist in separated coils, the sum of the separating spaces is to be deducted from the armature circumference.

The value of o is to be rounded off to the nearest lower even and easily divisible number, and, in the case of a drum armature, allowance for division strips, or driving horns, is to be made according to Table XIV. This table gives the average circumferential space occupied by the division strips in drum armatures of different sizes and various voltages, in per cent. of the core circumference. After fixing the number of armature divisions, which will be shown in Chapter 11, this table may also be used to determine the thickness of the driving horns, which are usually made of hard wood or fibre, and sometimes even of iron.

TABLE XIV.—Allowance for Division Strips in Drum Armatures.

Diameter of armature core, in inches.	Percentage of core circumference occupied by division strips— Up to 300 volts.	400 to 750 volts.	800 to 2,000 volts.
Up to 3	12%	15%	—
,, 6	10	12	15%
,, 12	8	10	12
,, 20	7	9	10
,, 30	6	8	9

Denoting one-hundredth of these percentages by k, the core circumference being unity, the formula for the number of wires per layer in a drum armature becomes

$$o = \frac{1{,}000 \times d_a \times \pi \times (1 - k)}{\delta'_a} \quad . \quad . \quad . \quad (9)$$

In toothed armatures the number of wires in one layer is found from the number, n', and the available width, s', of the slots by the equation:

$$o = 1{,}000 \times n' \times \frac{s'}{\delta'_a} \quad . \quad . \quad . \quad . \quad (10)$$

In this formula the value of s' is to be derived from the actual width, s, of the armature slots (Chapter 8), by deducting the thickness of insulation used for lining their sides, data for the latter being given in Chapter 10.

(*b*) *Height of Winding Space—Number of Layers.*—In dividing the available height, h'_a, of the winding space by the height, δ''_a, of the insulated armature conductor, the number of layers of wire on the armature is found:

$$u = 1{,}000 \times \frac{h'_a}{\delta''_a} \quad . \quad . \quad . \quad . \quad . \quad (11)$$

u = number of layers of armature wire;
h'_a = available height of winding space, in inches;
δ''_a = height of insulated armature conductor, in mils.

The height of the insulated armature conductor, δ''_a, in the case of round or square wire, is identical with its width, δ'_a.

The available height, h'_a, of the winding space is obtained from its total height, h_a, averages for which are given in Table XV., by deducting from $\frac{1}{32}$in. to $\frac{3}{16}$in. (see Chapter 10), according to size and voltage of machine, for the insulation of the armature core, insulation between the layers, thickness of binding wires, etc.

The nearest whole number is to be substituted for the value of u.

TABLE XV.—Height of Winding Space in Armatures.

Diameter of armature in inches.	Height of winding space in inches.—Smooth armature core.—Drum armature.	Ring armature.	Toothed armatur core.
Up to 2	·25	—	—
,, 3	·3	—	—
,, 4	·35	·20	—
,, 6	·4	·225	$\frac{3}{8}$
,, 8	·45	·25	$\frac{7}{16}$
,, 10	·5	·275	1
,, 12	·55	·3	$1\frac{1}{8}$
,, 15	·6	·325	$1\frac{1}{4}$
,, 18	·65	·35	$1\frac{3}{8}$
,, 21	·7	·375	$1\frac{1}{2}$
,, 25	·75	·4	$1\frac{5}{8}$
,, 30	·8	·45	$1\frac{3}{4}$
,, 40	—	·5	$1\frac{7}{8}$
,, 50	—	·55	2
,, 60	—	·6	$2\frac{1}{8}$
,, 70	—	·65	$2\frac{1}{4}$
,, 80	—	·7	$2\frac{3}{8}$
,, 90	—	·75	$2\frac{1}{2}$
,, 100	—	·8	$2\frac{3}{4}$
,, 125	—	·85	3
,, 150	—	·9	$3\frac{1}{2}$
,, 200	—	1·0	4

(*c*) *Total Number of Armature Conductors—Length of Armature Core.*—The product of the number of layers and the number of conductors per layer gives the total number of conductors on the armature, and this, divided into the total length of active armature conductor, furnishes the active length of one conductor—that is, the length of the armature body:

$$l_a = \frac{12 \times L_a}{\frac{o \times u}{p}} = \frac{12 \times p \times L_a}{o \times u} \quad . \quad . \quad . \quad (12)$$

where l_a = length of armature core parallel to pole faces, in inches;
L_a = length of active armature conductor, in feet, from formula (3);
o = number of wires per layer, from formula (7), (8) or (9), respectively;
u = number of layers of armature wire, from formula (10);
p = number of wires stranded in parallel to make up one armature conductor of area $\delta_a{}^2$, formula (4);

$\frac{o \times u}{p}$ = total number of conductors on armature.

For preliminary calculations an approximate value of the number of conductors, K, all round the pole-facing circumference of the armature may be obtained by dividing the conductor area found from formula (4) into the net area of the winding space. Taking ·6 of the total area of the winding space as an average for its net area in smooth armatures with winding filling the entire circumference, we obtain:

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$$\frac{o \times u}{p} = K = \frac{1{,}000{,}000 \times \cdot 6 \times d_a \times \pi \times h_a}{\delta_a{}^2}$$

$$= 1{,}885{,}000 \times \frac{d_a \times h_a}{\delta_a{}^2} \quad . \quad . \quad . \quad (13)$$

This result is to be correspondingly reduced for windings filling only part of circumference, or to be multiplied by $(1 - k)$, see formula (9), in case of a drum armature respectively.

In toothed armatures the average net height of the winding space is about three-fourths of the total depth of the slot, hence the approximate number of armature conductors:

$$\frac{o \times u}{p} = K = \frac{1{,}000{,}000 \times n' \times s' \times \frac{3}{4} h_a}{\delta_a{}^2}$$

$$= 750{,}000 \times \frac{n' \times s' \times h_a}{\delta_a{}^2} \quad . \quad . \quad . \quad (14)$$

In (13) and (14) the values of d_a, h_a, and s' are given in inches, and $\delta_a{}^2$ in circular mils.

(To be continued.)

RELATIVE ADVANTAGES OF TOOTHED AND SMOOTH CORE ARMATURES.*

BY ALTON D. ADAMS.

The merits of different methods of construction in the manufacture of dynamo-electric machinery, as in other lines, must evidently be decided by their comparative costs, all else being equal. Although questions concerning the relative merits of toothed and smooth core armatures have long been discussed, very little seems to have been written to show whether actual saving in cost may be effected by one construction over the other, when employed to produce the same results. The practice of dynamo-builders in this country and abroad embodies both types, and the history of the art records many changes from each to the other. In view of the above, the enquiry, whether in the light of present facts any saving can be effected by the use of toothed-core armatures, seems of interest. The limits of this paper do not permit consideration of this question in connection with all classes of electrical machinery, and its bearing on direct-current constant-pressure machines only will be taken up.

The principal advantages of toothed compared with smooth core armatures are greater first cost, large change of lead, excessive sparking, when used with too short air-gaps, and the production of heat in pole-pieces; their advantages are that inductors are positively driven, large solid inductors protected from eddy currents, and that a reduction may be made in the length and consequent magnetic resistance of the air-gap. Change of lead may be fixed within any desired limits, and sparking abated by such proportions of air-gap and teeth as give the sufficient magnetic resistance. Heat in pole-pieces may be reduced by their lamination, by the use of very narrow teeth and slots, by forms of teeth that present a nearly continuous surface of iron to the pole-pieces, and still more, by the use of openings in core discs which do not cut through their outside surface, or a continuous magnetic sheath outside the teeth. For any given form of tooth the heating of pole-pieces is less the longer the air-gap.

The mechanical strength of armature teeth as usually employed is far in excess of that required to hold inductors in position, even under conditions of short-circuit, and driving pins inserted in the core, at proper intervals, are much cheaper and take up less valuable room on the armature circumference. Either teeth or substantial driving pins are, of course, preferable mechanically to the slender bits of hard fibre which have been much used, and frequently give way under the heavy strains to which large generators are subject. When large wires of copper rods are used as inductors, their protection from eddy currents is an important matter, but proper stranding of inductors reduces the eddy loss in them, when used on smooth cores, to a very small amount, and has the further important advantage that inductors may be bent into the proper shape at armature ends, and the joints, when necessary rods are used, avoided.

The chief possible advantage, then, to be gained by the use of toothed armatures is through a reduction in the length of the air-gap, and the consequent reduction in the ampere-turns required on field magnet, weight of copper, or energy in winding, and the length and weight of iron core. To make this advantage available, it must be practical to use air-gaps shorter than are required for insulation, winding, and clearance. As is well understood, the armature winding of a dynamo or motor in operation has a magnetising action, which is measured in ampere-turns for a bipolar machine, by one-quarter the product of all the inductors of the armature into the total armature current. The ampere-turns on the armature evidently tend to set up a flow of magnetism, having a complete circuit through the armature core, twice across each air-gap, and through the iron of pole-pieces. About half the ampere-turns furnished by the inductors under pole-pieces evidently act against the field ampere-turns in each air-gap at the polar tips, and the ratio between the armature and field ampere-turns at this point, necessary to give sparkless reversal there, must determine whether the required magnetic resistance be greater or less than that of an air-gap long enough for insulation, winding, and clearance with a smooth-core armature.

As an armature coil in an operating dynamo or motor passes under the brush, the current flowing in it must stop, and one in the opposite direction be set up; and if this action is to be accomplished without sparking, a sufficient E.M.F. must be provided in the coil while in direct contact with the brush. In the ordinary dynamo or motor, magnetism forced across the path of the coil by the field ampere-turns expended in air-gap must provide this reversing E.M.F. The data of a number of smooth-core armature machines of different make show ratios of field to armature ampere-turns in air-gap of from about 1 and 1½ to 1 to 2 and 1½ to 1, and the writer's experience is that a ratio of 2 to 1 will give sparkless operation at full load, with brushes set just outside pole corners.

It is a matter of common experience that the ratio between field and armature ampere-turns in the air-gap may be so reduced, even in machines with smooth-core armatures, as to require excessive change of lead to secure even approximate freedom from sparking. If it be desired therefore to build machines having an expenditure of field ampere-turns in the air-gap not much greater than those of the armature, we need not resort to toothed cores. Take, for example, the case of a 260-ampere dynamo, with 120 inductors on its armature in one layer; an air-gap induction of 25,000 lines per square inch, and 80 per cent. of inductors under the pole-pieces. An air-gap of ·45in. between the armature and each pole-piece will be sufficient for insulation, winding, and clearance, and the field ampere-turns expended in each air-gap will therefore be 3,500, while the armature ampere-turns active under each pole tip will be 3,100. A considerable change of lead and sparking can be readily predicted for this machine.

In some types of small machines, the room required by insulation, winding, and clearance makes the air-gap longer than necessary for sparkless operation, and in such machines the utility of teeth seems to depend on their cost compared with the saving to be effected by their use. As the ampere-turns furnished by the inductors under any pole-piece grow less in a machine of given capacity when the number of poles is increased, very short air-gaps may be used, if the number of poles is sufficiently large. As an increase in the number of poles usually makes a machine of given capacity more expensive, however, the question at once comes up, to what extent the number of poles may be increased without a greater expenditure than the saving of iron and copper to be effected.

In large multipolar machines of four or six poles such as are commonly used, the length of air-gap required for sparkless operation is considerable, and those who have watched the development of these machines with toothed-core armatures during the last four or five years have seen the air-gaps gradually widen until machines of this character are not hard to find in which the copper inductors between the teeth could be taken out, wound outside

* A paper read before the American Institute of Electrical Engineers.

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the teeth, and still leave room enough for good clearance. Additional mechanical security, of course, furnishes a considerable argument for the use of teeth in very large slow-speed machines. A number of devices have been suggested from time to time, to enable toothed-core armatures to be used with short air-gaps, and the consequent saving in iron and copper effected. No machine with these devices, however, have yet stood the test of time and competition with those of ordinary type, and have yet to prove their ability to produce results, as at present attained at a less cost. The seeming opportunity to save material by the use of toothed armatures is very attractive, and we cannot but hope it may some day be practical; in the light of present knowledge, however, there seems little to be gained by their use in medium and large bipolar machines.

DYNAMOS FOR CHARGING ACCUMULATORS.

Dynamos used for charging accumulators, writes M. W. Rechniewski in *L'Electricien*, have to fulfil certain conditions which are not always very convenient, especially in the case where the same machine has to charge the accumulators in the day and serve at night for the supply of current direct to the lighting mains. It is necessary under these conditions that the machines should work at 110 volts in the evening for lighting, and that the voltage may be

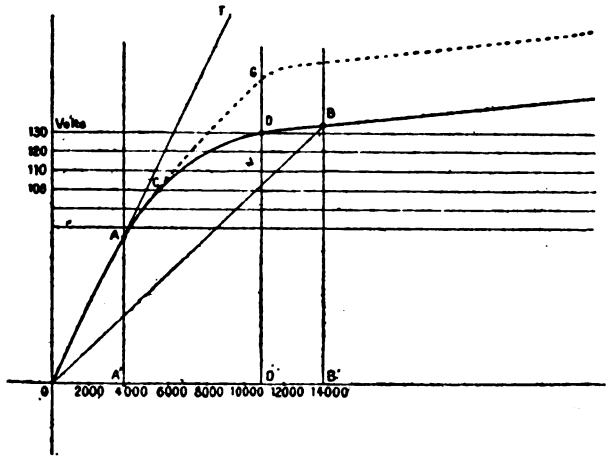

FIG. 1.

increased to 155 or 160 for charging the accumulators in the day. The difference of voltage is still greater when there is an appreciable loss in the line. Supposing the loss is 10 volts at full charge, it will be necessary that the dynamo should furnish 110 volts at a low charge for lighting, 120 volts at full charge for lighting, and 170 volts for charging accumulators. It is necessary that the machine should work under these different conditions without sparking, and that the running should be steady. That is the difficulty.

It is evidently easy to construct a machine working at 170 volts, but when we have to run it at 110 volts it has no steadiness, or the voltage increases beyond 110 volts, resulting in considerable variations in the lamps. Besides this, as the excitation for 110 volts is much reduced, it is almost impossible to run properly without sparking with such low charges. This inconvenience can evidently be remedied by varying the speed of the dynamo proportionately to the voltage required. This method would be admirable from the point of view of working the dynamo, which would thus run at a constant saturation, but it is impossible to employ it. In most cases in practice it is necessary to run at a constant speed. The steadiness of the voltage can also be assured by exciting the dynamo by the accumulators; by this means all the voltages can be obtained in a steady manner, but good running is not assured as regards sparking.

Further, it will not be possible to run satisfactorily without accumulators, which is very inconvenient, as a stoppage will be necessitated while the accumulators are disconnected when being cleaned or repaired.

Considering this problem, first, from the point of view of steadiness, we will take, for example, the characteristic presented in Fig. 1, which is that of a normal 20,000-watt dynamo. It is known that the tangent α of the angle $B\,O\,B^1$ is proportional to the resistance of the exciting circuit of the dynamo. By varying this resistance by moving the exciting rheostat, the voltage of the machine can be varied and a given resistance corresponds with a given voltage, provided that this angle α shall be less than that made with one of the abscissæ by the tangent O T of the characteristic at the beginning.

If the resistance becomes greater, the dynamo would become unsteady immediately. But it can be seen that the characteristic confounds itself with the tangent during a tolerably long course, in this case from O to A—that is to say, for the value of the exciting resistance corresponding to the angle $A\,O\,B^1$, the voltage may take any value between O and $A\,A^1$. There is consequently unsteadiness.

The dynamo cannot, therefore, work practically below $A\,A^1$ volts, and, moreover, it is prudent to keep above this extreme value. In the case of our figure, it would be inadvisable to descend below the point C—that is to say, of 100 volts. On the other hand, the heating of the field magnets does not allow of exceeding an excitation of 11,000 ampere-turns, corresponding to about 130 volts. The margin for this machine is thus only 30 volts. This margin, further, is reduced when we remember that the characteristic only represents the working of the dynamo running unloaded, and when loaded the reaction of the armature, as well as the inevitable slackening of the speed, considerably lowers the margin which has been found.

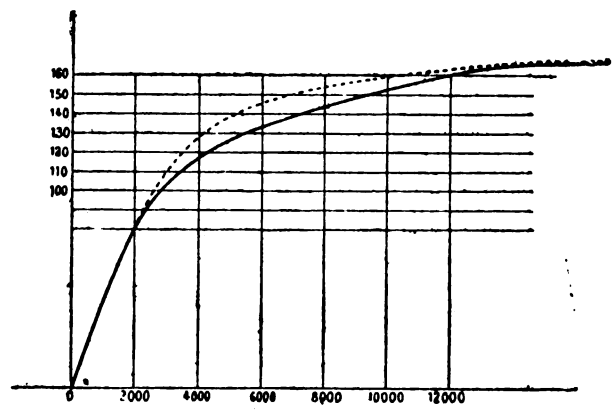

FIG. 2.

If on leaving the point C, where the running is even, one could prevent the characteristic from inflecting more, and make it take, for example, the direction of the dotted tangent in Fig. 1, we would arrive, for the maximum excitation allowed, $O\,D^1$, at a final voltage much higher, and at a sufficient margin for even running at 110 volts, as well as at 170 volts.

This is the manner in which the firm of Messrs. Postel-Vinay have solved the problem. In order to obtain a characteristic of the form in question, they employ armatures with very fine teeth, which are already saturated for 100 volts, whereas the field magnet and the armature are still far from the point of saturation. This saturation of the teeth of the armature produces the first bend of the characteristic at about 100 volts. From this moment everything happens as though the intervening iron of all the height of the teeth had been increased—that is to say, the characteristic again becomes rectilinear, but with a more feeble inclination than before, and this up to the moment of saturation of the field magnets and the armature where the characteristic inflects definitely and tends to become horizontal. The plain line of Fig. 2 represents the characteristic of a machine constructed on this principle, and it will be seen that the running, which is even at 100 volts, can still reach 150 for an excitation of about 9,000. The margin of 50 volts, which is found here, is more than sufficient, the loss of charge on the line being insignificant in this case. The same principle serves for regularly over-compounded dynamos. The dotted line in Fig. 2 shows what would be the characteristic of a machine made on the ordinary principle for 150 volts. It will thus be seen that the limits of even running are very nearly approached.

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THE
ELECTRICAL ENGINEER.

Published every Friday.

Price Threepence; Post Free, Threepence Halfpenny.

Editorial and Publishing Offices:
139-140, SALISBURY COURT, FLEET STREET,
LONDON, E.C.

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PACIFIC CABLE ESTIMATES.

We have kept our readers fairly well acquainted with the course of events which have occurred in connection with the Pacific cable scheme. It might, however, be well to recapitulate the salient points. The one great objection to the present system from the Imperial point of view is that at many points it is not under our own control, and, therefore, in a case of dire necessity would be practically useless to us. We do not mean to cast any reflection upon the existing system because it is not wholly under our own control, because it was originated and has been extended to a large extent from a mere consideration of commercial questions. The system, however, has been and is very largely subsidised, and therefore cannot wholly escape being examined in the light of Imperial questions rather than being kept absolutely within the bounds of commercial considerations. The system, too, is practically a monopoly, and such a monopoly rarely or never takes into consideration the wants of its customers till it is compelled so to do. This certainly has been the case with regard to the Eastern Cable Company and its connections. We contend that neither its customers nor its shareholders have ever been properly considered, nor have they received the returns which they might legitimately have expected in both directions—the one by remission of tariff, the other by an extension of dividend. It does not matter why, but some of the Australian colonies, the American colonies, and a good many of the business people in this country have become desirous of connecting Australasia to England through a cable which shall be wholly under English control. As we have so often stated, the present holders of the monopoly have strenuously exerted themselves to prevent such a cable being laid. We pointed out that this would be the case, and we also foretold that if the laying of a cable became imminent, the present holders of the monopoly would do all they could to obtain the control of this link in the telegraph chain.

It would require a volume to adequately criticise the various statements from this interested opposition, but it will suffice for our purpose if we give a brief digest of the method of climbing down which has been pursued in a recent and somewhat lengthy correspondence carried on in the columns of the *Times* regarding the establishment of a cable across the Pacific. In this correspondence one cannot but be struck by the graceful ease with which the opponents of this scheme vary the results of their estimates. Let us take these *seriatim*, premising that in every case the scheme is credited with an annual Government guarantee of £72,000.

(1) In a protest submitted to Lord Ripon by the "existing companies" it was pointed out that, taking the present traffic between Europe and Australasia at 1,300,000 words annually, any company undertaking a cable across the Pacific would find an annual deficit of £120,000 in their accounts.

(2) In speaking of this project, Sir John Pender informed the shareholders of the Eastern Extension Telegraph Company at the last annual meeting that £165,000 per annum would have to be made up by

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the earnings of the line. He goes on to say that as the value of the *whole* existing traffic with Australasia, if directed to the Pacific, would only produce about £90,000 at the proposed reduced rates, there would still be a deficit of £75,000 to be made up (this means that if the Pacific cable took only *half* the traffic the "deficit" would be £120,000—*see supra*).

(3) In a letter to the *Times* dated May 30, Sir John Pender estimates "loss to investors" at £48,000.

(4) In a letter to the *Times* dated June 6, Sir John Pender estimates loss to investors at £10,000.

To the above varying figures we may add that, if the traffic for the year 1893 be correctly stated in the Australian papers, it is over 1,401,000 words, which is about 7¾ per cent. more than the figures taken in the above estimates; this would mean another "climb down," leaving a "loss to investors" of only £6,500. With the above varying results in view, it is evident that a little judicious persuasion might prevail on Sir John Pender ultimately to show a balance on the credit side of this account, instead of £120,000 against it.

If we have correctly stated the case, no one can for a moment suppose that the figures which have at various times been put forward have been put forward with any desire to be accurate, but purely and solely with the desire to obtain an adverse influence to the project. We always have inclined to the opinion that where a *bonâ fide* increase of facility is given to business men, there always is and there always will be an increase of business. The history of the Australian negotiations with the Eastern Extension Telegraph Company and others has been full of choppings and changes, variations of tariff, playing off one colony against the other, and, generally, no real attempt to meet the wishes of the colonists with any liberal spirit. In the consideration of this Pacific cable scheme, we have, then, to admit that there must necessarily be an extremely long length of costly cable with no earning capacity from branch lines, or practically no earning through the Pacific except from the American coast to the Australian coast. Its revenues will have to be derived from the two ends of the systems, rather than—as is the case with the existing system—from these ends combined with the various points where the cable is tapped. That is the great commercial objection to it, but its promoters maintain that, with the facilities they are prepared to give, the business from the ends will be, when combined with the subsidies, sufficient to guarantee the shareholders a fair dividend. From the consideration of the adverse criticisms we should be inclined to think that their statements are fairly correct, otherwise Sir John Pender would not have varied his deficit from £120,000 to £10,000. A critic who admits these great variations having, as he ought to have, all the facts of the case before him, is not worthy of credence; and we trust full consideration will be given to the statements made by the promoters of this scheme as to its earning capacity, and this, combined with the admitted utility from the Imperial point of view, ought to enable the scheme to be carried through.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

"OUR REVIEW OF REVIEWS."

SIR,—My free copy reached me this morning. Sam says he got three. He then turned up the "County Councillors' Directory," and remarked that the names came in handy. I notice that Gas "Meter" hashed up something about Portsmouth and the stage and society. I do not know what the stage and society have to do with it. Years ago the engineering papers described the Holden system of burning liquid fuel. Gas "Meter" now trots this out as a new thing. Mr. Kapp discourses on the electricity works at Cologne and Amsterdam. I know the former (but forget about the latter) was described in the electrical papers two years ago, and the working results for two years have already been published in the English journals. But anything is new in a sheet which is not a journal. Sam then came across two columns of padding, called "Our Review of Reviews." He says it is a handy fill-up for want of something better. The padding, probably abstracted before the owner left Bedlam, contains a pat on the head for your French contemporary *L'Electricien* in the fashion of you kiss me and I'll kiss you. The *Revue d'Electricité* is snarled at, and the French journal *La Nature* is drawn upon for half a column. It is so wonderful, Sam says, how well they understand French. The Waterhouse meter, which you described last week, now turns up again. Mr. Chestnut, jun., then fills up some pages of padding on commercial matters which everybody read in the financial papers a fortnight ago. The *Contract Journal* is apparently drawn upon for a copy of the programme of the meeting of the Association of Municipal Engineers, and also, it would appear, for announcements of open tenders. The final padding is a copy of a letter addressed by Mr. Maxim-um-joke to the daily papers. Your contemporary has been unable to find room for the numerous columns of American matter usually given. Poor old "William," too, seems to be absent. Perhaps the cake he ate at the Institution conversazione has not yet been digested. All the same, I hope to see his cheery face again next week, when I shall be able to again give you "Our Review of Reviews."—

Yours, etc.,
JOHNNY.

Timbuctoo, June 19, 1894.

REFUSE DESTRUCTORS.

SIR,—In your leader of last week's issue, in calling attention to the possible results to be obtained in town-lighting by utilising the waste heat in the process of burning house refuse, you quoted Prof. Unwin's estimate of the quantity of refuse collected from each individual as varying from one to four tons per annum. This is rather a wide margin on which to base an engineering calculation, and you very rightly in your remarks used the inferior limit indicated. It is, however, pretty generally known to municipal engineers that this quantity of one ton per head of the population is much in excess of the actual collection, which rarely exceeds half a ton per head. Had you before penning your remarks looked at Mr. Jones's book, to which you referred, on refuse destructors, you would have found many statistics bearing on this point, the best being perhaps the table giving particulars of the London vestries, from which it appears that a population of two and a half millions produce three-quarters of a million tons of refuse, or three-tenths of a ton per head, per annum. Then again, the quantity of refuse required to produce 1 h.p. you quote as 40lb.: this result may possibly be obtained at some future time, but up to the present I believe 1 i.h.p. for 60lb. is about the nearest approach to your figures which has been realised in actual practice on a large scale. If, therefore, you divide the amount of refuse you calculated on by 3 and knock a further 60 per cent. off your horse-power results, you will then more nearly arrive at a fair estimate of the power available for lighting purposes. After this deduct your losses in transforming and leads, and bearing in mind

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that street lamps are required to run 14 hours out of 24 in the depth of winter, you will, I think, arrive at the conclusion that, however successful the system of storage of power may be, there is not even sufficient power for public lighting alone, without going into the question of private lighting. No good purpose can be served by taking exaggerated views of questions of this sort, and although I am quite prepared to admit that the waste heat produced in destroying town refuse is not utilised so much as it might be, yet, on the other hand, the general public should not be led to suppose that there is a gold-mine in it, as at one time they were taught to believe about sewage sludge.—Yours, etc.,

E. J. SILCOCK.

King's Lynn, June 18, 1894.

THE PORTSMOUTH CENTRAL STATION.

SIR,—We have read with much interest the report of the Portsmouth Corporation works in your issue of the 8th inst. It is, we believe, admitted by all that this plant, as designed by Messrs. S. Z. de Ferranti, shows great developments, and in many respects is novel and original.

May we, therefore, be permitted, through your valuable medium, to correct what appears to us a misprint in the detailed description of the "alternators." "Mica tubes" are therein mentioned. The insulation for this machinery was, however, supplied by us, and the word "mica" should read "micanite." You are probably aware that this insulator is a form of mica insulation, until introduced by us, almost unknown in this country, or even Europe. Since we claim by this patented process to be able, as in this case, to show infinite advantages over the old method of mica insulation, we trust that you will give publication to this letter.—Thanking you in anticipation, yours, etc.,

BERGTHEIL AND YOUNG.

ELECTRIC LIGHTING FROM THE GAS POINT OF VIEW.

The inaugural address before the Incorporated Gas Institute was delivered on Tuesday by Mr. John West, M.I.C.E., president. In comparing the cost of electricity and gas, the PRESIDENT said:

A short time ago an opportunity was afforded me of impressing upon the gas consumers of Manchester the desirability of improving their present antiquated system of gas-lighting, by adopting the modern regenerative or other economical burners, whereby rooms may be ventilated and an equivalent light obtained at a cost from 2½ to 3½ times less than the Corporation would be able to supply the electric light for, from a large central station, as the following calculations will show:

Incandescent Electric Lamp.—16-c.p. lamp lasts 1,000 hours, and absorbs 60 units of electricity at 8d. per unit, 40s.

Ordinary Gas-Burner with Manchester Gas.—16-c.p. is equivalent to 4 cubic feet of gas per hour, or 4,000 cubic feet in 1,000 hours, cost of which at 2s. 6d. per 1,000ft., 10s.

In the above calculation I assumed that the Corporation charge the Board of Trade limit of 8d. per unit for the electric light; and even at that figure grave doubts exist in my mind if they would be able, after paying working expenses, repairs, and maintenance, and providing for a sinking fund, to hand over any profits to the Council, as is at present done by the gas department.

As a proof that lecturing is useful, I was attending only three weeks ago a meeting of general engineers in Manchester, and was asked by the president (at the desire of some of the members) if I would explain to the meeting what were the best and most suitable burners to adopt. The question arose from the reading of a lecture given by Prof. Lewes at the Society of Arts, where he stated that if the best and most scientific burners were used, the gas bills would be reduced. I, of course, did my best to explain the principle of combustion and the theory upon which good burners were constructed; and I advised them as to the best burners to use, so as to obtain the greatest amount of light from the gas, which would enable them to reduce their gas bills—that is, if they were satisfied with the same light that they had formerly obtained. They were so interested in the subject that I am to be called upon to further enlighten them on some future occasion. If the advantages of gas are so great over the electric light where the ordinary flat flame was used in Manchester, how much greater must be its advantages when regenerator and incandescent burners are employed, in which 3¾ cubic feet of gas produce a light of from 70 c.p. to 80 c.p. at about one-eighth the cost of the electric light.

A number of the general public do not seem to be aware that the electric light is produced chiefly from the same source as you produce light—viz., from coal; the difference is that you make the light-giving gas by the distillation of coal in closed vessels, and that, after the gas has been produced, you have valuable products left. In fact, you utilise the energy in the coal more completely, in a commercial sense, than the electrician can; and this enables you to produce a given quantity of light from gas from three to three-and-a-half times cheaper than the price for which the equivalent electric light can be sold so as to produce the same profit that is being derived from the manufacture of gas. If some of the public like to pay for the electric light as a luxury, there is no doubt that installations within reasonable areas, with gas-engines as the motive power, will be found the most reliable and economical, and, from a sanitary point of view, far better than the large number of steam-boilers that are being put in our midst for the purpose. Only a few days ago I inspected an installation of electric lighting at a hotel not very far from this building. There were two large semi-portable boilers with undertype engines, and a large room set apart for containing storage batteries for supplying a few hundred incandescent electric lamps; and this plant required at least two men to look after it during the 24 hours. The whole thing looked ludicrous in my eyes, when I knew that many of our village gasworks are erected and managed for a less sum than this single electric installation.

It is now a well-known fact that a gas-main will deliver sufficient gas to generate 5,000 h.p., or as much more as you please, at a long distance—say, three or more miles—at from three to four times less than the same power can be transmitted for by electric cables. Again, the "load-factor" is a great drawback to the electricians. They cannot store their energy as you do in your gasholders; hence their fuel account comes out very high per unit produced. In many cases they use the best boilers and steam-engines; and they will tell you that they can produce, with 2½lb. to 3lb. of coal, one Board of Trade unit. In practice, however, if you look at the accounts of the electric light departments, you will find that they have, in some way or other, used in many cases about 12lb. of coal per unit, and how to get over this difficulty has been taxing the brains of electricians for a very long time. I find, from calculations, that the Gaslight and Coke Company deliver from Beckton to London—a distance of seven miles—through only two of their mains sufficient gas per hour to produce, in ordinary gas-engines, about 125,000 h.p., the power expended in transmitting this quantity being less than ¼ per cent. of the total. It would be interesting to know the cost of an electric cable to convey this power the same distance, and the loss in transmission.

GAS-ENGINES FOR ELECTRIC LIGHTING.

The members of the Société Industrielle du Nord de la France on May 30 had presented for their consideration a paper by M. Aime Witz, on "The Price of Energy Supplied by Gas-engines." The author first referred to the experiments which, as mentioned in this journal some time ago, showed that more light could be produced by driving dynamos by gas-engines than by burning the same quantity of gas in gas-burners. He then detailed how gas companies had been obliged to establish in their own interests central electric light stations to protect their threatened monopoly. The initiative in this movement had been taken, the author observed, in Germany, but

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there were now 16 stations in France where the motors were gas-engines.

As these stations adjoined the gasworks, the companies were able to retain their consumers, who would discontinue their patronage if the gas companies would only supply them with gas. M. Witz estimated that, generally speaking, it was possible under these circumstances to supply a hectowatt-hour at 10 centimes, at the same time realising a fair profit, and he established this figure after a detailed examination of the working expenses, interest, and redemption. But in many cases consumers would derive considerable advantage by organising among themselves and erecting sub-stations for the supply of a small collection of houses in rich districts. The owners of cafés, hotels, and large warehouses and a certain number of houses could by combination provide themselves with light at a low cost, and for this purpose it would only be necessary to lay down a motor and a dynamo. M. Witz found that with gas at 15 centimes per cubic metre, the annual price of 150,000 lamp-hours with 16-c.p. lamps worked out at 5·33 centimes per hectowatt-hour. When the consumption is increased to 450,000 lamp-hours the price becomes reduced to 4·18 centimes, and to 3·52 centimes in the case of 1,500,000 lamp-hours. These figures are based upon balance-sheets in which provision had been made for interest and redemption at 15 per cent., but without allowing any profit. But the expenses are much reduced, because the wiring of a collection of houses as mentioned does not extend any distance. Central stations may, then, fear competition from groups of houses served by a dynamo driven by a gas-engine. If the gasworks will only supply their gas at a too high price, then the gas-engine must be furnished with poor or inferior gas In this case, the cost price per kilowatt-hour is further diminished. The following are the figures given by the author for a group of 1,000 lamps (65 kilowatts):

INITIAL COST OF INSTALLATION.

Supply of water and gas (meters)	£120
One 120-h.p. gas-engine	1,200
Foundation, installation, and piping	232
Shafting and belts	200
Dynamo and cost of erection	500
Conductors and accessories	348
Total	£2,600

WORKING EXPENSES (FOR 97,500 KILOWATT-HOURS).

Rent of engine-room	£40
Wages of attendant	48
Gas	743
Water	39
Oil	101
Interest and redemption at 15 per cent.	390
Various	11
Total	£1,372

Thus we have the following figures:

Cost of establishment per lamp	£2	12	0
Cost price per kilowatt-hour	0	0	3½
„ per 16-c.p. lamp hour	0	0	0¼

The author concluded by mentioning various examples of this kind.

THE GAS AND ELECTRICITY SUPPLY OF BLACKPOOL.*

BY WILLIAM CHEW, M.I.E.E., BLACKPOOL.

To the members of this institution, consisting of gas engineers, the part of this paper having reference to electricity may, perhaps, be thought a subject foreign to their interests. At one time, no doubt, this would have been the case; but the development of electrical knowledge during recent years has placed in the field previously held by gas a new agent, as a competitor therewith, for lighting, heating, and motive power. As this new agent seems destined to create a disturbing element in the future prospects of the gas industry, and as the advisability, or otherwise, of having a dual supply is occupying the attention of local authorities throughout the country, I propose in this paper to lay before you an account of the work undertaken at Blackpool which I trust will be of interest to the members generally. The town of Blackpool, as most of you are aware, is the seaside watering-place of Lancashire. Its requirements may therefore be taken as typical of those of other towns, and the grounds on which the Corporation decided to have a dual supply are also applicable elsewhere, though perhaps in a less degree.

Commencing with the gas supply, as being the oldest and most important undertaking, let us examine how far it has fulfilled its purpose, and wherein lie the shortcomings that render it at all necessary to have an auxiliary supply by means of electricity. Without going into ancient history, which is well known, as to the origin of any gasworks, it is evident that at some time or other the Blackpool Corporation became possessed of such works, and at the present time, in addition to their original purpose of lighting only, have added that of supplying an agent for cooking, heating, and motive power. Experience has proved to them that for these purposes the use of gas has been well adapted and thoroughly reliable; and that, from a monetary point of view, it could be sold remarkably cheap in comparison with other agents, and at the same time yield a handsome profit on the investment. However satisfactory these results in the use of gas may have been in the past, we must not overlook the fact that advances have been made of late years in matters of hygiene, and already this class of criticism has been brought to bear on the use of gas, with a view to discourage its adoption wherever possible. Exception is now taken to the combustion of gas in the production of light, and in this lies the chief advantage attributable to electricity as a lighting agent. Under ordinary conditions of usage, light from gas is obtained by combustion—the waste products and heat generated being radiated in the surrounding space; and should this happen to take place in a badly-ventilated room, it will tend to further vitiate the air thereof. Further, with some classes of burners an amount of unconsumed carbon is released, and this combines with the deleterious particles floating on the atmosphere of rooms, depositing itself at times in inconvenient places. I am aware that these drawbacks to the use of gas have been greatly exaggerated and apply only in a slight degree in the majority of uses to which gas is put. But taking as an example an ordinary apartment, where gas is only used about four hours out of the 24 on an average, we find so many counteracting agencies at work, that any chemical theories built upon the basis of the constituents of burning gases are rendered almost neutral in their application, owing to the circulation set up in a heated room from unseen sources. Were this not the case, owing to the depletion of oxygen and the increase of carbonic acid that can be calculated to have taken place in a room through the use of illuminants—such as gas, oil, or candles—the same would soon become uncomfortable for habitation, but such does not happen where ordinary ventilation is allowed to take place. Nevertheless, we find that there are a good many cases where ventilation is neglected, and circulation takes place in a haphazard sort of way; and as the tendency of the age is to have much more light than formerly, the result in such instances is an aggravation of existing evils. It is in this direction, then, that gas scientists must turn their attention if they are to meet these modern requirements; and already there are signs of a new era dawning for the production of light from gas, on the lines of the Welsbach burner, which, besides cheapening the cost of light, has far higher hygienic properties than previous burners in use—so much so that already its sale has had a marked effect in limiting the use of electric light on the Continent, where the burners have been introduced on a large scale. These are the principal arguments advanced against the use of gas, and it is with a view to obviate these drawbacks that some sections of consumers are turning their attention to electric lighting. We know that the requirements of all consumers are not alike in this respect, and that there are a certain number to whom it is a matter of importance to have a lighting agent giving a low calorific effect, with freedom of combustion and a certain convenience of manipulation. To these the question of cost is sometimes a secondary consideration in comparison with the advantages supposed to accrue indirectly. It was for this reason, and on the assumption that there were many of this class of customers in our town who could well afford to pay for such lighting if made available for them, that our Corporation decided to put down an electricity works to supply the central parts of the town.

Before finally deciding to proceed, opportunity was taken to enquire into the demerits as well as the merits of the new system and its properties generally, in comparison with gas lighting. The plant required for its production was found to be much simpler than gas plant, a rotary alternator driven by an engine being all that was required to produce it on a large scale. But the distributing plant was more complicated, owing to the absolute necessity of having an uniform pressure. From this cause, it appears that, although the

* Abstract of paper read before the Incorporated Gas Institute.

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amount delivered could be measured approximately by meter, yet it did not always follow that a given amount registered produced the same amount of light, even with the same lamps in use. Again, a most important factor was met with in the instability of the secured custom of large consumers, owing to the facility with which a private installation can be put down, and, if worked with cheap gas power, the electricity produced on the spot at less cost. This was soon manifest, for already in Blackpool there are four private installations in operation having a working capacity of 200 units, or equal to the size of the central electricity works. So important does this question become, that immediately after the capital is expended the large customers are practically able to determine the price charged within very narrow limits to themselves, otherwise their custom, so essential to success, is lost, thereby entailing charges for unemployed plant, etc.

Electricity yields light or heat whenever a suitable resistance is offered to its passage, and this property is taken advantage of to obtain light in incandescent lamps. By means of raising a fine thread filament to incandescence (which can be accomplished by proportioning its thickness to the pressure and quantity of electricity passing through it), various degrees of light and heat are produced. The terms used to express these quantities in technical language are as follows:

Resistance.—The standard is called an "ohm," being the resistance offered by 129 yards of No. 16 copper wire.
Volt is the standard of pressure.
Ampere ,, ,, quantity.
Watt-hour ,, pressure × amperes × hours.
Unit ,, ,, kilowatt-hour, or 1,000 watt-hours.

As I have already mentioned, the production of light depends on the quantity and pressure being maintained. So much so is this the case that, taking an ordinary incandescent lamp placed on a town main, where the pressure should be maintained at 100 volts when the standard light given out is 16 candles, should there be any falling off in pressure, the light diminishes at about seven times the rate of the drop. Thus, should the pressure fall (say) to 96 volts, the light given will be reduced to about 12 candles; and if the pressure rises above 100 volts, the opposite is the case. Then, again, the life of a lamp varies with the change of pressure as follows:

Standard at 96 volts, 2,700 hours' life, yields 12 c.p. nominal.
,, 100 ,, 1,000 ,, ,, 16 ,,
,, 105 ,, 300 ,, ,, 20 ,,

Throughout the nominal life of a lamp the light gradually diminishes; so that the real effective life is much less for lighting, if we assume a lamp to be used up when the light drops from 16 c.p. to 14 c.p. The result of this to a consumer is that, although he may pay for a certain quantity of electricity, there are many considerations before he gets his equivalent in light.

The method of charging for light affords a similar analogy to that of gas where the consumer, buying light, is supplied with a unit of gas, called 100 cubic feet—costing 3d. at Blackpool—which will yield him, when burnt in a standard burner, 3·6 sperm candle-power per hour from each cubic foot used. In burning gas, however, the result depends on a minimum pressure being used, and this is under control at each burner—the pressure in the mains being kept slightly in excess of actual requirements in consequence. Although electricity is not sold in cubic feet, yet it fortunately so happens that the unit by which it is measured yields nearly the equivalent in light of 100ft. of gas, so that for purposes of comparison of cost a unit of electricity and 100ft. of gas approximately correspond. Electricity, then, is charged by the unit, and this is equivalent to the quantity of electrical energy supplied in one hour by a current =one ampere, which, multiplied by the pressure, yields 1,000 watt-hours, and is commonly called a kilowatt-hour. Applying this rule to lighting, it is known that an ordinary long-life incandescent lamp takes four watts per candle for each hour used, but there are short-lifed ones that can be had, taking 3 or 2½ watts per hour only. The best lamp to use is a matter for experts to decide; for, owing to the fluctuation in pressure on town mains, the rapid diminution of luminosity at different pressures, and other causes, it involves almost a mathematical calculation suitable only to electricians. Until we get a lamp that will maintain a standard light, there are other costs incurred besides those for current, just as there are in some forms of gas-burner. For outside lighting and large spaces with arc lamps, these remarks do not apply; as for this purpose, I think electricity has no rival in the field. These, then, are a few of the results found to be inseparable from an electrical supply; and when it is known that it is a physical impossibility to maintain an even pressure on all the mains, it will be patent that these are no little obstacles to be overcome as soon as the electrical company have emerged from the embryo condition in which most works are now placed.

As to the relative direct values of the cost of lighting, irrespective of the little shortcomings of both systems, the following is an approximate estimate of the cost of maintaining a 16-c.p. light by gas and electricity at Blackpool. For 1,000 hours per annum under all conditions:

BLACKPOOL GAS.—Standard Value, 18 c.p., charged at 3d. per unit, or 100 cubic feet.

Burner used.	Candles per foot.	Cost of 1,000 hours.	Add maintenance.	Total.
Argand	3·6	11s. 0d.	1s. 0d.	12s. 0d.
Special	3·0	13 3	0 6	13 9
Common	2·5	16 0	0 3	16 3
Bad	2·0	20 0	—	20 0
Regenerating ...	10·0	4 0	Not	known.
Welsbach	20·0	2 0	Not	known.

BLACKPOOL ELECTRICAL SUPPLY.—Standard Incandescent Lamp, 16 c.p., charged at 6d. per unit.

Incandescent lamps, watts per candle	Watts 16 c.p.	Life of lamp (estimated).	Cost of 1,000 hours.	Maintenance.	Total.
4	64	1,000	32s. 0d.	1s. 6d.	33s. 6d.
3½	56	750	28 0	2 0	30 0
3	48	500	24 0	3 0	27 0
2½	40	—	20 0	Not	known.
2	32	—	16 0	Not	known.

These tables are necessarily founded on estimated cost, and are only to be taken inferentially—actual tests not having been made under ordinary working conditions. After reviewing all the foregoing facts, it is palpable that electricity as a lighting agent has a certain commercial value, and given the possibility of sufficient support at the commencement of the undertaking, there is no reason why this agent should not be utilised to general advantage. This was the view taken at Blackpool before starting the works. I should here mention that still further confidence was given by the Corporation having had an electrical station going for 13 years previously, so that they had some knowledge of their own of its capabilities. In this works of an older type electricity used to be produced at 3d. per unit, and on a larger scale, with modern plant, it was expected a less figure would be reached. During the periods between these years various estimates were got out for a general scheme; and, as showing how unnecessary caution had perhaps been used, it was always assumed that a constant supply would be required, and under the knowledge at that time obtainable it was considered impossible from economical grounds. Eventually, after seeing the working in other towns, this was ignored, and we started to supply from dusk till midnight, which is now increased to an 18 hours' supply out of 24, although a compulsory supply can be demanded constantly. It is owing to the electric companies not always fulfilling their obligations that a good deal of preliminary success is attributable. Concluding these remarks on the subject, I will take the opportunity to describe the manufacturing plant of both agents, commencing with a description of the gas plant and following with that used for the supply of electricity. As a result of the year's working gas is now reduced to 2s. 4d. per 1,000ft., with a free meter.

(To be continued.)

TRANSMISSION OF POWER FOR MINING PURPOSES

An interesting illustration of the application of diphase alternating currents has been carried out at the Decize coal-mines belonging to MM. Schneider and Co. The generating station is situated at distances of 3·1 miles and 1·86 miles respectively from the most distant parts of the mines supplied with electrical energy. It contains six boilers and two steam dynamos, each of 100 kilowatts, and a third unit of the same capacity will ultimately be laid down. The two sets already installed can be operated separately or in parallel. The engines, which run at 200 revolutions a minute, are of the horizontal non-condensing type, and drive the alternators by belting. Each set of generators comprises two machines, arranged one at each end of a shaft, the driving pulley being placed between the two. The alternators are of the Zipernowski six-pole type. The exciting current is furnished to each pair of alternators by a direct-current dynamo actuated by belting from

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the shaft of the generators, the current required for the two alternators being from 25 to 30 amperes at 110 volts. The magnet coils of the alternators revolve, whilst the armature is fixed. The conductors, which are mostly carried overhead on poles 25ft. high, are of silicon bronze, and are supported on porcelain insulators. The diameters of the wires is 6mm. for the main line and 4mm. for the other. At intervals of 540 yards the wires are crossed so as to annul the effects of induction on the telephone wires carried at the middle of the same posts. In this connection it is interesting to note, according to an article in *L'Industrie Electrique*, that although the return of the telephone is formed by the earth, no difficulty has been experienced in the transmission and comprehension of speech. The end of the principal line and of the telephone wire towards the Chagnats pit alone are placed underground. In this case lead-covered cables laid in wooden conduits have been employed. Lightning protectors have been provided at different parts of the line and at all the stations. The electromotors used are of the same type as the generators, with the exception that they have twice the number of poles. One motor of 30 h.p. is installed at the Fendue des Lacets, and a second of the same power at the puits des Coupes. A third motor is now being put down at the Chagnats pit. It is noteworthy that these motors are practically left to themselves, an attendant making an inspection every six or eight hours. The substations in which these motors are installed are situated in the forest, and the only indication of the presence of the motors is the hum caused by the ventilating fans which they drive. In addition to these motors there are two others which respectively operate hauling machinery and pumps, whilst at the same time some 24 arc lamps and 600 incandescents are lighted from the same generating plant.

THE GLASGOW CORPORATION ELECTRIC LIGHT STATION.

In our issue of May 18 was published an abstract of the paper read by Mr. William Arnot, A.M.I.C.E., before the Institution of Engineers and Shipbuilders in Scotland on "The Corporation Electric Light Supply." We also gave a report of the discussion, which has since been completed and printed in the *Transactions* of the institution. The resumed discussion is as follows:

Mr. M'Whirter said he must congratulate the institution on the paper put before them by Mr. Arnot. It had thrown a great deal of light on the installation of electric lighting in Glasgow. Mr. Arnot had given sufficient information to those who were able to follow the paper to desire more light. Some parts of it were very clear, but the very parts—speaking for himself—that he was most in the dark about were the parts that were not so fully explained as they might have been. He trusted that Mr. Arnot, in his reply to the discussion, would make a large addition to what he had already put before them. Mr. Mavor differed very strongly with the Glasgow Corporation for the system of electric lighting they had adopted. That was only to be expected. He was satisfied that they had so far adopted the right system, but he could not see how it was they adopted the absurd voltage of 200. Certainly it would have been much better had they adopted 220 or 230 volts. There would have been a gain of 10 or 12 per cent. in the distribution of current, and there would also have been a very great gain in the working of arc lamps from the system of electric lighting. It was a well-known facts that 100 volts was altogether too neat for working the arc lamps that they had at their command at the present time, but even 100 volts could not always be got. He found the voltage recently to vary more than four volts, so that when they took that off it was quite sufficient to cause the lamps to feed when they really ought not to have done so. He thought it a very great pity, indeed, that 100 volts should have been adopted. That was 200 volts between the outside mains. On the question of efficiency he had no doubt at all the Glasgow installation showed very well, a compound efficiency between the engine and dynamo of 88 per cent. commercial, and 17·5lb. of water per horse-power, which was all that one could desire. They could point to very few cases of the transformation of energy where anything approaching this was done. If they had adopted the alternating system, he did not think they would have got an efficiency exceeding 66 per cent., or something like that, so that here there was a clear gain of 20 per cent. in conversion. There might be, however, as was mentioned by Mr. Mavor at the last meeting, a considerable loss in the distribution as compared with the alternating system. Coming down to the question of accumulators, he could not say that he approved of the adoption of these in their present capacity in Glasgow. They were only able to carry on the lighting for a very short period of the 24 hours. He did not happen to know what the cost of these cells was, but he thought it would reach something like £2,000, and if they took that £2,000 at 13 per cent., which he thought would soon be required, although they were told by the makers and others at present that the maintenance charges was practically nil, yet those who have had accumulators know that 13 per cent. is nearer the cost of maintenance than anything under it. (**Mr. Mavor**: 30 per cent. is nearer it.) He had no doubt at all that the introduction of accumulators in this system was done with the view of saving money, but if they took £260 he was quite certain it would do more than fill up the interval over which the accumulators carried on the lighting by direct working. Of course, there was another thing to add to that. From the accumulators not more than 85 per cent. efficiency was got, so there was another 15 per cent. gone there. Mr. Arnot called attention to a system of keeping the cells in good order, where he said: "There are six cells as repair cells, or, as they are sometimes called, milkers. From these plates are taken to replace faulty ones in the working set, and should a cell show any weakness it is not allowed to discharge for a day, but is short-circuited by two milkers in series. It has thus four volts across it." He was assuming that the faulty cell had got a back E.M.F. of 2½ volts. That was, they had 1½ volts tending to send a current through that cell. Assuming for the sake of argument that the resistance of the cell was only ·001, or something less than that, it appeared to him they would have something like 1,500 amperes going into the faulty cell. Perhaps there was some other arrangement, and, if so, they would be glad to know something about it. About the underground mains Mr. Arnot did not say very much. Mr. Arnot said nothing about the insulation of those mains, but perhaps he would kindly give them that. Speaking as a telegraph engineer, he never saw such an attempt at insulation as in Glasgow. He did not think the resistance in ohms exceeded three figures. That being so, there was something going on continually that some day would be very serious. Supposing the resistance were taken at 300 ohms, that would mean, with 200 volts, an ampere of current loss. If they had an ampere of current going to waste, it meant 18 grains of copper being removed from the positive conductor every hour, or something like an ounce of copper per day. How long was that going to continue before there was anything very serious? The installation of the underground mains was very far from what it might have been. Mr. Arnot gave them very little information about feeders. The system of feeders enabled the potential to be kept constant all over the system. There were several ways that could be done. It could be done by connecting a dynamo between every pair of feeders. If that was done, unless there were a number of places where the amount of current carried by the feeders was identical, and the resistances were identical so that the potential at these places should be the same, then one dynamo must be run for each pair of feeders. Another way was to introduce resistance into the feeders, which meant loss. A better way, and a purpose for which he thought accumulators were admirably adapted, was to bring about this regulation by the use of accumulators, inserting, withdrawing, or reversing as required. This last was economical, and did the work exceedingly well. Mr. Arnot stated that they had decided in Glasgow to paint the negative red, and he gave them his reason that it was because there was a paper used for pole finding, which, when touched by the negative pole or wire, there was a red mark produced. He had been looking into that, and had a lot of papers giving red, blue, brown, or green, and it was difficult to see why an installation like Glasgow should have changed what had been use and wont for many years—*i.e.*, the positive conductor had always been painted red since ever there were any distinguishing marks used, so why it should be changed and the negative made red, the actual reverse, for such a simple thing as the colour produced by a pole-finding paper, was something beyond his knowledge. He thought, when they had a system which had been carried out practically all over the world, that there should be some solid ground to bring about such a change. There was another interesting matter which Mr. Biggart brought up at the last discussion. That was the question of cost. Unfortunately, Mr. Arnot had not run the station a year, and until that time they could not get it, but they hoped to get it in another paper, and he might then let them know the profits the Corporation were making. The present charge, he believed, was 7d. per unit, or, if compared with gas, it was something like gas at 7s. per 1,000ft. That meant that those who used electric lighting must consider it a luxury, but, of course, there were certain benefits which reduced this price. For example, there was less painting and cleaning, and the lights were not required to be always burning, and when these things were taken into account and compared with gas it was something like at the rate of 5s. per 1,000 cubic feet. When they kept in mind that there was a company in Newcastle supplying electricity at 4½d. per unit, and paying a dividend of about 5 per cent., and who had actually been paying a dividend over the whole period of their existence at the rate of 4 per cent., there was certainly something that the Electrical Committee of the city of Glasgow required looking into, and in support of that, in Bradford, where the conditions were almost identical to what they were in Glasgow, the cost of production was only 2·57d. per unit; and in Glasgow, without going to Bradford or Newcastle, there were many instances where gas-engines were supplying a unit of electrical energy with a consumption of 30ft. of gas, or, say, 1d. per unit, so that there was something wrong with the system, or the public of Glasgow were being very much overcharged—perhaps a little of both. He certainly could not see that there was any inducement to anyone requiring much lighting to take power from the Corporation mains so long as the price was anything approaching the amount being charged now, when they could get a gas-engine to

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give them the same at much less cost. They knew how little attention a gas-engine required, and the cost of the engine, interest, and depreciation was easily ascertained, and added to the penny per hour would certainly make a very small item.

Mr. H. A. Mavor said that since last meeting he had come to the conclusion that a discussion of this sort was not long enough to enter into the whole question, and he would confine himself to the discussion of the station as it stood, and perhaps his other remarks might be embodied in a paper which he might read next session. In the discussion at last meeting he stated that he might look forward to engines of 10,000 h.p. being used. He was trusting to his recollection for figures. Ten thousand horse-power was about the size of a generating station suitable for one district of Glasgow, so that, of course, the individual engines would be much smaller. Coming now to the station as it stood in Waterloo-street, the first striking difficulty that appeared to one was what led the Corporation and its engineers to place the station there. Every ounce of coal had got to be carted to the place; there was no water available for the condensers; the ground was dear, and it was by no means in the centre of the district which was to be supplied. The next peculiarity was the size of the unit—that was to say, the size of the individual dynamos that were laid down for the work. The station had about 1,862 h.p., and it was proposed to increase this to about 3,000 h.p. Mr. Arnot had shown that engines of the type used would run economically at half load, so that there was no economy in having engines in a smaller ratio of relative size than ½, that was to say, that when the smaller engine was fully loaded up, No 2 might start to run efficiently where No. 1 left off. Examining the existing plant on this basis, it would be found (the balancing dynamos being left out of account because of their adaptability for very light loads) that the second existing plant bore a ratio to the third of $\frac{1}{1.5}$, and the second to the largest of $\frac{1}{1.5}$, which would be quite a fair ratio. Therefore, all the arrangement of intermediate sizes, and the resulting complication of steam-pipes, wires, switches, etc, was unnecessary. The arrangement of the station for 3,000 lights on the lines which Mr. Arnot's paper clearly proved might have been adopted with perfect economy, should stand as follows: Taking the balancing dynamos and engines as they stood, the second engine would have been 300 h.p. instead of 160 h.p., as it was now. The third engine would be double that size, or about 600 h.p. To double that engine would lead to another difficulty. It was advisable in a lighting station to so arrange that the breakdown of any one plant should not interrupt the efficient working. It might be assumed that if a station was well designed, and the engines were working easily at their full normal load, it would be a safe thing to overload these engines by 30 per cent. In fact, for a short time a good dynamo might be worked at double its normal load, as might be seen from the load curves. The time of the full load was only a quarter of an hour during the whole year, and therefore the risk of having to run the plant 30 per cent. overloaded for a quarter of an hour was not a serious risk. The size of the units would, by this consideration, be limited to about 700 h.p., and that might be taken, for the purpose of this argument, as the limit to the size of an engine in a station of 3,000 h.p. Argued out in that way, there would be for the 3,000 h.p. four large engines, one small one, and two little balancing engines, or seven engines in all of three different sizes. What had been done in the Glasgow Corporation station? There were 13 engines in the complete plan; the biggest one was 350 h.p., and the engine-room was like a toyshop. From the load curve on December 26, which was about the date of the heaviest curve in the year, it would be seen how rapidly the load runs up from about one-fourth of the output of the station right up to the top inside of an hour. Now the trouble that was involved in the starting of no less than 12 engines between the top and bottom of that load might be imagined, and it seemed a manifest absurdity that this trouble should be incurred. There were still three engines of 350 h.p. each proposed to go down, and he hoped the Corporation would be persuaded to put down as big engines as the place would hold, and abandon this duplication of ridiculously small units. Four years ago on a visit to New York he had occasion to call attention to what seemed to be a similar mistake which was being made by the Edison Illuminating Company. They were arranging a new station, which was now the Elm-street station, and they proposed to proceed with 600-h.p. units, which were just as small in proportion to the size of their works as the units here were—in fact, smaller. Very strong representations were made to them, and these were successful so far as to be an element in the considerations which induced that company to send their chief engineer to visit this country. He spent some time on this side, visiting London and the Continent, and when he went back he increased the size of the units—although, in the speaker's opinion, they were still too small, and before the station was complete probably the size of the later engines would be increased. For the Elm-street station as it stood it was proposed to use ten engines of 2,000 h.p. each. Returning to Waterloo street, there was no necessity for having any main engine smaller than 630 h.p., but as a concession to risk of breakdown one of 360 h.p might be admitted. A great delusion in possession of the minds of many electrical engineers was that it was necessary, even at large capital cost, to save the last ounce of coal in a generating station. It was good to work economically, but it must not be done at too great a cost. Probably it was with a view to economy that so small units were used, but it was carried to an absurd extreme. The cost of the station as it now stood had been, he estimated, from £2,500 to £3,000 more than it would have been if engines of the size spoken of had been put in. It was difficult to see what argument could be found for the use of such small units, unless it were what must be, after all, a fairly strong argument, that the biggest engine in the Glasgow station was the biggest engine of the type which had been manufactured at that time by Willans and Co.; that might have been fair excuse in the circumstances under which the Glasgow Corporation were placed. They had to get quick delivery of the engines, and were obliged to buy them from a maker who could take the pieces out of stock. Willans and Co. were able to do this. Looking to the large area still to be lighted, he thought it would only be fair to ask the Corporation to begin their arrangements in time to enable them to ask Clyde engineers to offer for the next engines, and give them time to make them. On the question of storage batteries, he had tabulated a debtor and creditor account, with blanks for Mr. Arnot to fill up, and he hoped he would do so. There was on the debit side: sinking fund or cost, rent or charge for space, attendance, repairs and upkeep, loss of energy in difference between charge and discharge at 1d. per unit. On the credit side: coal and attendance saved. He thought that although it would be interesting to have those figures, it was perhaps hardly fair to ask for them, because the money would probably be all on the one side. He did not think anything could be shown for storage batteries on the credit side of the account. It was no doubt a great help to the engineer to have storage, because it enabled him to shut down and make repairs on steam-pipes, etc., and upon this no definite money value could be put; but he maintained that that could be as well done in the Glasgow station by having a 100-h p. gas-engine, or a turbine driven by water power from the hydraulic mains at high pressure, either of which would be as convenient as a storage battery. He had the pleasure of seeing in Antwerp such an hydraulic arrangement, and nothing could be more simple, and probably the cost would be much less than that of storage batteries. He did not think it would be fair to charge the Glasgow Corporation with all the unfortunate difficulties that Mr. M'Whirter had referred to as having taken place in the underground mains. Still, he could not help thinking that the system of iron culverts and bare wires, would, even with the best workmanship, be unsatisfactory; and, in view of the probability of putting the middle wire to earth, this method was almost certain to be abandoned in favour of some more trustworthy and safe system of running underground wires.

Mr. Mavor said he was anxious that his arguments on large engines should have some effect, and, therefore, that they should not be misunderstood. He did not propose that the station should be run by two engines. It would be quite clear that his argument had two elements—first, that there is no economy in having in an engine less than twice the size of its predecessor; and, second, that the size of the engine is limited to one-fourth of the total output of the station. With these two arrangements they had provision for economy and provision against breakdowns.

Mr. Sam Mavor said he thought the wisdom of the choice of engines was open to question. Engines of this type had certainly given very satisfactory results in the matter of economy, but the records of their use for central-station purposes extended over a comparatively short period. The conditions experienced by electric lighting engines on board ship were often exceptionally severe, but the fact was that double-acting engines by many well-known makers had successfully withstood these conditions, while engines of the type in question had succumbed. The faults which developed rapidly under severe conditions would probably also develop in longer time under more favourable conditions. His own experience of the Willans engine in the smaller sizes had been extremely satisfactory; but he believed that central-station engines of the marine type, of which there were so many examples at work on the Continent at speeds of about 120 revolutions per minute, would still be doing hard work after the engines in the Glasgow central station were used up. With regard to the battery, he failed to see why a battery should have been used in Waterloo-street, especially bearing in mind the fact that the arc lamp plant was also put in Waterloo-street. The primary use of the battery in such a case appeared to be to allow the boilers to be shut down and to save a shift of men, but in Waterloo-street there was the necessity for it to be run every night and all night. The battery certainly was a decided convenience in switching the load off and on when adding on or taking off a dynamo, but the cost and complication seemed to be quite unwarranted by the very slight gain which it could show in this case. With regard to the mains, if Mr. Arnot had not too much to reply to, he would like if he would, in giving the information as the mains, give them the insulation of each wire. He had heard from some of the other three-wire stations that they found a difficulty with the negative conductor. The negative wire was said to go to earth, but that if the wires were changed round and the negative made the positive and the positive made the negative wire, the wire which was positive would go to earth and the negative come up. Mr. Arnot might give the result of his experience with regard to this phenomenon. With regard to Mr. M'Whirter's remarks about producing electricity by a gas-engine, it was rather absurd to say that a man having 100 lights would be better to have a gas-engine of his own. It was a matter of the number of hours during which these lamps were used. If he had a 100 lamps and wished to use them for a 100 hours per annum only, he had to spread his £300 over the 100 hours, and the cost would be out of proportion when the number of hours each lamp was in use came to 600 hours per annum. Then it came to be a question of whether it was cheaper to use a gas-engine for generating on the premises, or taking a supply from the Corporation, and herein lay a very important question which the Corporation would have to face. It meant that those consumers who used the lamps for over 600 hours per annum were the best-paying customers, and unless the Corporation would bring down the price below 7d. per unit the Corporation would lose those customers. It is also meant that in a large warehouse consumers would put down plants sufficient to do the portion of lighting which it would

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pay them to do, and they thus not only deprived the Corporation of all the paying portion of the lighting, but they switched on to the Corporation mains the portion which it would not pay them to do, and certainly would not pay the Corporation.

Mr. Rankin Kennedy, in a written contribution, stated that he thought the site chosen for the generating station most unsuitable. It should be a first requisite in choosing a site that it be either on a railway siding, on a river bank or canal, for convenience of carriage. He also thought that the system adopted was not the best for a city like Glasgow. It was contended that it was the best for the area for which it was designed; that, however, was a moot point, but was not now worth discussing. The low-pressure continuous-current system adopted could not in the future be extended to other parts of the city, and even if it could the site chosen was not fit for a larger station. That the low-presure continuous-current system was unfit for extensive supply was admitted practically by the designer of the Glasgow station—was proved by the fact that he had advised a mixed system for Edinburgh—a combined continuous-current and alternating-current system. The remarks of Mr. Mavor in regard to the steam-engines used he fully endorsed. In the United States the necessity for large well-designed engines was now recognised, and on the Continent of Europe large marine engines were now adopted. In London, and in some other places, the electric lighting was in the hands of companies: in Glasgow, and other places, it was in the hands of corporations. This fact made a difference apparent to any engineer who could make an estimate of the value of machinery and electrical plant. The corporation plants were pretty much stereotyped copies of one another, and ran up to a large initial cost per lamp capacity. The companies seemed to get much more for their outlay. As the paper was a descriptive one only, it could not afford much room for discussion. The practice at the station was quite orthodox, and might be expected to give the usual results common with such well-known machinery, and some few years must elapse before it could be criticised on actual results of its working. The proposal to put down similar stations when electricity was required in other districts, was not likely ever to be put in practice; by the time these were necessary it was to be hoped that better counsel would prevail. The large central station, like the gasworks, was the station of the future, distributing at high pressure to the various districts.

Prof. Jamieson said the first thing that attracted attention in Mr. Arnot's paper was the want of uniformity in describing the plant. For example, he mentioned the names of the makers of such simple matters as steam-pumps and feed-water heaters, but omitted the names of those who had constructed the boilers, dynamos, etc. Moreover, he had given but a very imperfect idea of the general arrangement of the central station. If the statements regarding the number and sizes of the engines employed had been neatly tabulated, they should have been better able to follow Mr. Henry Mavor in his remarks about the size of the units employed, to which he took such vigorous exception. Both the wall diagram and one of the figures showing the "switchboard" connections were so unconventional and complicated that he was certain very few of those present would take the trouble to try and comprehend them. He had therefore prepared what might be termed an "educational diagram." When this was compared with its corresponding "index to parts," there would be no difficulty in grasping the leading principle of the whole arrangement. The great advantage of depicting complicated electrical connections in this way was very apparent. Mr. Arnot had given a minimum amount of information regarding the insulation and general behaviour of the main conductors and their feeders. They should like to learn from him (1) what was the lowest safe working insulation resistance of the whole system at any particular time? (2) what proportion of the whole current was lost by leakage in the mains? (3) what was the proportion of the power generated to that paid for by consumers? He mentioned an interesting and novel method of fault-finding without informing them who devised the same, or how near a fault could be "spotted" thereby as compared with other methods. His remarks on this subject would have been better understood if they had been accompanied by a diagram. He (Prof. Jamieson) held very different views from those expressed by Mr. Henry Mavor in regard to the size of the units into which a central station should be divided. In the first place, the greatest economy resulted when engines and dynamos were worked at full load. Consequently, it was most advisable to be able to increase or reduce the amount of the plant in action at any time, so as to correspond as nearly as possible with the public demand for current. If the central station contained but two large slow-speed engines and alternators, each capable of bearing the maximum load, they should not only have a needlessly large percentage of spare plant, but the working of the machinery would be at a very low average output, and consequently at a low efficiency. Further, it was preferable to adopt high-speed direct-coupled engines to slow-speed belted engines; for, if the latter were employed, they must synchronise not only the alternators but also the engines. The extension of the Glasgow central station could be best carried out by placing suitable gas-engines and dynamos at several points on the circumference of the system. Whenever those in charge at these outlying sub stations observed the pressure falling below the normal, they could start their plants in a minimum of time, and thus help the central station to meet the demand. Mr. Biggart had asked a very pertinent question—viz., what was the relative cost of gas and electric lighting? He was of the opinion that Mr. M'Whirter's reply to this question was too favourable to the latter. For, with Glasgow gas at 2s. 6d. per 1,000 cubic feet, and electricity at 7d. per Board of Trade unit, it only required simple proportion to prove that candle for candle they were being charged at the rate of 9s. 5d. per 1,000 cubic feet of gas for their electric light.* But is the supply of electric light at this price paying the Corporation? Suppose that the whole capital hitherto expended by the Corporation amounted to £120,000. They paid 3 per cent. for the loan of this money, and 7 per cent. could not be said to be too much for depreciation, so that they had 10 per cent. of the £120,000 to lay past annually as a first charge. Now, their income from the supply of current for public and private lighting certainly did not amount to more than £15,000, thus leaving less than £3,000 per annum to pay the staff and run the two stations. Consequently, if they were not making a profit at 7d. per Board of Trade unit, they must wait a little before clamouring for a reduction.

Mr. Arnot said he had to thank them for the very appreciable way in which they had received the paper which he had the privilege to read. Replying, he said, Mr. M'Whirter asked the question: why adopt the 200-volt pressure? The reason that pressure was adopted was the circumstance that 5,000 lamps were already being supplied at 100 volts. The Corporation had to maintain that supply, and if they had altered the voltage they would have had to supply lamp renewals to these customers. Reference was made to a case in which the voltage was low in a certain part of the town. The reason of that, he said, was due to the works which are being carried out in Argyle street by the Caledonian Railway. The feeder could not be laid as intended. As a consequence the distributing main had to be increased, and acted as a feeder for a time; the rise and fall in the voltage was due to this cause, as the potential of 100 was kept constant at the far end of the distributing main. The feeder had now been completed. There was a case lately at one part of the town where a consumer complained of the voltage being low. When enquired into, it was found at that particular spot the balance was not right. The connection was made on the other side, the balance restored, and all cause of complaint removed. Why was the negative painted red? He did not make the negative red, nor did he suggest the negative to be made red. It was red in London before it came here. It was a matter of no importance whether it was red, green, or scarlet. The consulting engineer brought it to Glasgow; that was how it was adopted. Referring to the feeders, he said they were not regulated by different rheostats nor by separate dynamos on each feeder. A single dynamo could be put on any individual feeder. It had never been found necessary to raise the potential of any of the feeders above the others. All had been run from the common omnibus bar. The copper resistance of the feeders was calculated and adjusted to a certain load. The network for the distribution being continuous throughout a city, he found the load equalised itself, and the potential was quite easily maintained constant at the different feeding points. He had not found the difficulties spoken of, and he was quite confident that when the difficulties did come the staff would be able to cope with them. The insulation of the main was an important matter. On Sunday afternoon, at 3 o'clock, he measured the outgoing current on a Kelvin balance. He sent the current out on one feeder, disconnecting all the others; the readings were—on the positive, 8 amperes, on the negative side, 17·9 amperes. He knew there were lights in the post office, in a number of jeweller's shops, and other places, they burned a pilot light constantly, and there were lights in the kitchens and underground offices of such places as clubs, and in the lighting stations there were a few lights. On that same Sunday the insulation resistance of the street mains, with all the work on consumers' premises attached—it was found that few broke their main switch—on the positive side was 860 ohms to earth; the middle wire was 710 ohms to earth, and the negative side was 70 ohms. It was the case that the negative side got gradually lower, but it was not a dead earth. On connecting a very low-resistance ampere gauge between the positive wire and earth the current was to-day 1·5 amperes. Referring to Prof. Jamieson's remarks on the switchboard, he said perhaps there were too many connections and too many wires shown, but he purposely did that that they might have a correct drawing in the *Transactions* that they could study at their leisure, and if it was not understood now it would be at a future date.

The **President** said Mr. Arnot had given a very important paper, and the discussion had been very interesting. This year a great variety of subjects had been read before the institution, and which a number of them were not able to discuss. Such a scheme as that was still in its infancy, and if it had been extended on the whole to this year it might not have been too late to remedy the mistake the Corporation had already committed. He hoped every magistrate and town councillor would obtain a copy of the *Transactions* of the meetings which have been held, and in the future extension of that system that the discussion should take place here before it was two late—perhaps before the work was commenced—and specifications and plans be brought before them here, so that they would be able to give the Town Council authorities a decision as to how they were to proceed. He proposed that the institution should give Mr. Arnot a hearty vote of thanks for his paper. Mr. Andrew Wilson was to have exhibited a model of an apparatus for lessening the rolling motion of seagoing vessels, but as it was too late it would require to be postponed to the next session.

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* For, 5 cubic feet of gas per hour gives a light of 20 c.p., ∴ they had $1,000 \div 5 = 200$ hours of lighting for each 20-c.p. burner, or 200 hours $\times$ 20 c.p. = 4,000 candle hours for 30d. But an average 16-c.p. Ediswan electric lamp requires 65 watts ∴ 1,000 watt-hours, or one Board of Trade unit, will light 15·4 lamps for one hour. Or, $15{\cdot}4 \times 16 = 246{\cdot}4$ candle hours for 7d. ∴ if x = equivalent price of gas per 1,000 cubic feet, we have, by proportion, $246{\cdot}4 : 4{,}000 :: 7 : x$, ∴ $x = 28{,}000 \div 246 = 113$d. = 9s. 5d. Or, the present cost of the electric light in Glasgow is 3·76 times the price of gas at 2s. 6d. per 1,000 cubic feet.

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THE HISTORY OF WOODHOUSE AND RAWSON UNITED, LIMITED,

As Detailed in the Bankruptcy Court.

MONDAY.

The public examination of the directors and officers of Woodhouse and Rawson, United, Limited, was commenced on Monday before Mr. Registrar Hood, at Bankruptcy-buildings, Carey-street. The Company was registered in July, 1889, the signatories to the memorandum and articles of association being Lord Aberdare, Mr. Philip Rawson, Sir Thomas H. Farrer, Sir John Stokes, K.C.B., Sir Albert J. Leppoc Cappel, K.C.I.E., Colonel C. E. Howard Vincent, C.B., M.P., Sir John Coode, K.C.M.G., and Mr. F. L. Rawson. The Official Receiver in his observations upon the case states that the Company was formed for the primary purpose of amalgamating the businesses of Woodhouse and Rawson, Limited, electrical engineers, and other companies. The gross liabilities are returned in the accounts at £212,628, of which £14,713 are expected to rank, with estimated total assets £211,772, subject to claims of debenture-holders £166,482, and to preferential debts £940, resulting in an estimated surplus of £29,626. The deficiency as regards contributories is £448,321. The Official Receiver states, however, that the receiver for debenture-holders does not concur in the value of the assets given in the accounts, his opinion apparently being that it is doubtful whether they will realise sufficient to pay off all the claims of the debenture-holders. It appears that Mr. F. L. Rawson has furnished a detailed statement as to the causes which have led to the Company's insolvency. Briefly given, these are (1) that the industrial portion of the business was, during the earlier stages of the Company's history, "unduly pushed under inadequate supervision," and (2) that heavy losses were incurred as a result of the litigation between the Company and the Edison-Swan United Electric Lighting Company, and also by reason of the general depression in trade and finance, necessitating the curtailment of some portions of the Company's business, and that, while these difficulties were in course of being overcome, the Company's operations were brought to a standstill by the action of a consultative committee appointed in December, 1892, whose report, presented after some delay, was absolutely destructive to the Company's credit and reputation.

Mr. C. J. Stewart attended as senior official receiver; Mr. Muir Mackenzie, Mr. H. T. Eve, Mr. J. A. Cartmell, Mr. C. E. Jenkins, Mr. Stirling, and Mr. Pilling for directors and others interested in the proceedings; and Mr. W. M'Kay (Ward, Perks, and Co.) for debenture-holders and also for the Official Receiver.

The **Official Receiver** stated that considerable delay had taken place in obtaining a sitting for public examination owing to the great difficulty experienced in ascertaining the facts and to the non-production of a large number of books and original documents, and he had not been able to obtain any satisfactory explanation with regard to them.

Sir John Stokes, K.C.B., was first called, and in reply to the Official Receiver stated that he was a director of Woodhouse and Rawson, Limited, and subsequently became the liquidator of that Company. The books were ordered to be destroyed by a resolution of the shareholders when the liquidation was closed in November last, the resolution being proposed by him as chairman. He had never heard it suggested that the books would be required under these proceedings. He could not say whether one of the minute-books had been destroyed or not, but he had not seen it since the close of the liquidation.

Mr. F. L. Rawson said he was aware that the books had been destroyed under the resolution mentioned, but he was not aware of the resolution being passed.

Sir Albert J. Leppoc Cappel, K.C.I.E., was next called, and, in reply to the Official Receiver, stated that he was one of the original directors of Woodhouse and Rawson United, Limited. He joined the Board at the request of Mr. F. L. Rawson, who represented to him that four excellent industrial undertakings were to be acquired, which, for reasons of general policy and economy and management, it was thought desirable to combine into one, and he was informed that the Company would make a good deal of money by "fostering" patents.

The **Official Receiver**: Which came first—the industrial branch or the "fostering" of patents?

Witness said it was undoubtedly an industrial undertaking. He believed that, with the exception of one small one, the companies acquired were carried on at a profit. Numerous meetings of the directors were held before the incorporation of the Company, when the whole matter was gone into, and he attended most of them. He was unable to recall at the present moment the enquiries which were made as to the various concerns to be acquired. He recollected seeing a valuation made by Mr. H. Edmunds in April, 1889, of the patents which were to be taken over, in which they were valued at £159,265. The prospectus which was subsequently issued set forth that the patents had been "valued by competent experts and the value placed upon them has been the guide in fixing the purchase-money."

The **Official Receiver**: Did you understand that the valuation referred to in the prospectus was an independent one?

Witness: I did.

The **Official Receiver**: Were you aware that the actual language of this valuation had been drafted by Mr. F. L. Rawson?

Witness: Certainly not.

The **Official Receiver**: I take it you would have looked with doubt—I will not say suspicion—upon the valuation if you had known that it was drafted by Mr. F. L. Rawson, he being practically the vendor?

Witness said that if he had possessed the knowledge he would have left the place then and there, and have had nothing to do with the Company. According to his recollection the Elmore patents were not included in that valuation, and he certainly was not aware that these patents were included in it at the sum of £120,000, thus reducing the value of the patents acquired from £159,000 to £39,000. The Company acquired the patents for £85,000, but if he had been fully acquainted with the facts, he would not have agreed to pay that amount for them. The purchase price paid for the businesses was £269,000, the goodwill being agreed at £97,000.

The **Official Receiver**: Why did you pay such a large sum for the goodwill?

Witness said he believed the undertaking was a successful industrial one with a valuable connection, which with good management and supervision would prove very remunerative. It was represented to him that the profits earned by Woodhouse and Rawson, Limited, for the year ending June 30, 1888, amounted to £21,440, and the profit for the succeeding year was estimated at £75,000. He learned after these figures had been published in the prospectus that they were somewhat qualified by a report of the accountant, which stated that the profits represented were partly made up by shares in other companies. To a certain extent that knowledge caused him to feel some doubt as to the accuracy of the statements in the prospectus. It now appeared that the balance-sheet for the year ending June 30, 1888, included about £35,982 in respect of shares in three companies. He could not say that he made a complete investigation into the businesses acquired. He had not had any previous experience in company matters, and as the whole of the negotiations were completed in about one month he considered they were very much "rushed." His feelings of uneasiness and anxiety gradually increased, and he became very determined about the Company going to allotment. He was not satisfied with the amount of applications received for shares and debentures. Immediately after the prospectus was issued he began to think there was a want of order and exactness in the manner in which the whole matter was conducted. At a Board meeting held on July 30, 1889, it was resolved by a majority of the directors that unless applications were received for at least £200,000 the money should be returned and they should not go to allotment.

The **Official Receiver**: Immediately that decision was arrived at I believe you were "fired at" by several legal gentlemen?

Witness said he received letters from several solicitors to the various businesses which were to be acquired, informing him that unless he agreed to go to allotment proceedings would be instituted against him for damages. There was a striking resemblance in the lawyers' letters, but he could not say whether they were the production of the same mind. After consulting his colleagues he resigned his seat on the Board, and a circular was sent round to the applicants for shares, stating the reason for his retirement, as well as that of Sir John Coode and Colonel Howard Vincent. It appeared from the circular that Sir Leopold M'Clintock, Sir Rawson W. Rawson, and Mr. Samuel Pope, Q.C., had consented to take their places; that further subscriptions for shares had been received, and that the allotment would be proceeded with. He stipulated that the circular should be sent out because he felt, if anybody had been attracted by his name to the concern, that they should have an opportunity of taking the course of withdrawing from it, which some actually did. The fact that he and his two colleagues who retired were the only three who were entirely independent of the vendor companies only came to his knowledge after they refused to go further into the matter.

By **Mr. F. L. Rawson**: He remembered several meetings taking place with reference to various matters connected with the business then in hand. Witness looked into the agreement in order to see that the best possible terms were obtained by the purchasing company. He took a great deal of trouble at the time, but could not tax his memory as to details. He was not in a position to say whether the Company paid considerably less for the patents than the amount at which they were actually valued.

By the **Registrar**: The directors obtained the advice of their solicitor respecting the patents, and upon questions of title.

Further examined by **Mr. Rawson, Witness** said that so far as he was aware there had been no refusal on the part of the Board to return the subscriptions of shareholders who had applied for the repayment of their application money in consequence of the circular announcing the retirement of three of the directors. The more he looked into the matter, the less he liked it.

Colonel Howard Vincent, C.B., M.P., was next examined by the Official Receiver. He stated that he consented to join the Board on July 19, 1889. He regarded the Company as an industrial and not as a financial undertaking. He soon became dissatisfied in consequence of the unbusinesslike manner in which the negotiations were conducted. No proper record of the meetings was kept, and difficulty was experienced in obtaining information. He knew that the firm of Woodhouse and Rawson was established in 1881.

The **Official Receiver**: Are you aware that the only transaction in which a profit was made to any extent was in respect of a "deal" in Elmore shares, when a sum of £78,000 was realised?

Witness said he was not aware of that fact.

By **Mr. Muir M'Kenzie**: The other provisional directors had taken pains to investigate the properties to be acquired. The negotiations, however, were unduly hurried, and sufficient time was not afforded for a full investigation.

Mr. F. L. Rawson said it had been alleged that he had made a profit in connection with the promotion of the Company, but he denied this, and asked the witness whether he knew it to be a fact.

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Witness: I do not think that anyone has ever suggested that you worked for nothing.

Mr. Rawson: But I have never received a shilling in respect of promotion money.

Witness: Then I am very sorry for you.

TUESDAY.

The first witness called at the resumption of the proceedings on Tuesday was **Mr. Charles L. Baker**, who stated, in reply to the Official Receiver, that he formerly acted as managing director of C. L. Baker and Co., Limited, which was a company subsequently acquired by Woodhouse and Rawson United, Limited. About the beginning of 1889 he came to London on business and called upon Woodhouse and Rawson, Limited. Mr. F. L. Rawson approached him, and informed him that an amalgamation scheme was being considered, and asked if C. L. Baker and Co , Limited, would also amalgamate. The matter was shortly afterwards brought before the directors and shareholders of the last-mentioned company, and, it being pointed out that unless they agreed to the scheme their company would have to encounter very serious opposition, they agreed to the proposition. It was said that all the other companies concerned in the scheme were doing good business. He would not say that the directors of C. L. Baker and Co., Limited, understood that a large proportion of the proposed Company's business would consist of financial work or company promoting. It was known, however, that patents relating to electrical work would be "fostered." He was not aware of the sums to be paid for the other businesses acquired, but he knew that only an exceedingly small cash payment was to be made. C. L. Baker and Co., Limited, received in all £24,000 for their business, being as to £5,000 in cash, and £19,000 in preference shares, the amount for goodwill being £9,000, which was represented by *bonâ fide* profitable contracts. Independent valuations were made of the plant and stock, and he was of opinion that they were undervalued. He saw the prospectus before it was issued, in which it was stated that the profits of Woodhouse and Rawson, Limited, for the year ending June 30, 1888, amounted to £21,440. He was not aware, however, that the auditors submitted a report upon the assets which represented that profit in which they stated that "the accounts are in accordance with the books of the Company, but it is obviously impossible for us to be responsible for the net profit, owing to the nature of the assets and the Company's interest in many trading concerns." Mr. F. L. Rawson assured him that great care had been exercised in the preparation of the prospectus, and he understood that every statement contained in it was correct. He was subsequently informed that a difficulty had been raised about going to allotment, owing to three of the directors being dissatisfied with the amount of capital subscribed. He thereupon pointed out that if, from this cause, the Company did not go to allotment, most serious injury would be inflicted upon C. L. Baker and Co., Limited, as this company had specially stipulated that they should not be dangled before the public as a bait, and he therefore instructed his solicitor to acquaint the directors of the United Company with his intention to proceed against them for damages if they declined to go to allotment. From an interview he had with Sir Albert Cappel, he gathered that that gentleman had some doubt in his mind as to the success of the concern. He had also seen many adverse criticisms in the financial papers, but, knowing what they were, he did not take any notice of them. The Company, however, went to allotment, and witness was appointed general works manager at Cadby Hall, Kensington, and Cornbrook Telegraph Works, Manchester. He had had considerable experience in managing works of this kind, having been for a great number of years an electrical engineer. Shortly after the Company was started, he became aware that a sum of £85,000 had been paid for the patents acquired by the Company.

The **Official Receiver**: Did you form any opinion as to their value?

Witness said at the time he thought they might have been worth from £30,000 to £50,000, but now they were practically worthless, there being only one or two which were workable, but this was owing, to a great extent, to their being superseded by other inventions.

The **Official Receiver**: I believe the industrial branch of the Company's business has been a failure throughout its existence, has it not?

Witness said that very heavy losses had been incurred, but he attributed this to the fact that the business had been cut up and distributed, instead of being carried on under the management of one person. He did not think the losses in question amounted to £50,000. The foundry at Kidsgrove, Staffordshire, was purchased by the Company for £30,000, in shares. It was represented that the business carried on there was producing £8,000 a year profit, and, thinking that they were acting in the interest of the shareholders, the directors decided to acquire it. As a matter of fact, it had shown a considerable loss, and the directors estimated that the property had depreciated to the extent of £17,784 in July, 1892. When he entered upon his duties at Cadby Hall he experienced a considerable amount of difficulty in ascertaining anything about the concern, and to a great extent he was regarded as an interloper. Upon enquiry he discovered that affairs were in a very unsatisfactory condition, and upon his representing the same to the directors they expressed some surprise, and Sir John Stokes said he was disgusted with the state of things. In April, 1892, he sent a letter to each of the directors calling their attention to the position of matters, and suggesting certain alterations, but no action was taken upon it, and no mention of the matter was made to him. His only explanation of this was that the Board must have been engaged on more important business at the time. Ultimately he was unable to obtain funds for the purpose of carrying on the works, and a large proportion of the experienced hands were dismissed. In his opinion there had not been sufficient funds provided from the commencement, and difficulties had been experienced throughout. In the balance-sheet for 1891 there was an item of £3,425 included as an asset in respect of a "moiety of special expenditure on advertising, repayable by instalments." Witness took exception to this amount, and contended that it should not be included as an asset, but his objections were overruled. Shares to the value of £2,000 were given to him as his interest in C. L. Baker and Co., Limited, but at the date of the winding-up order he did not hold any of them, because he knew too much about the concern. He had realised from £3. 12s. down to 3s. 6d. for a £5 share. He had also purchased other shares in the Company when his faith in it increased, but these had also been disposed of.

In reply to **Mr. Muir Mackenzie**, the **Witness** said that when the business of C. L. Baker and Co., Limited, was transferred to the United Company he believed it was in a flourishing condition and capable of realising a large profit. When he joined the United Company he had every reason to believe that with good management it would have been a prosperous company.

Witness was also examined by **Mr. F. L. Rawson**, and stated that he had never heard it suggested that the latter had ever acted in a manner which was other than straightforward.

By a **Creditor**: At the time C. L. Baker and Co., Limited, was transferred it was a profitable concern, but it was impossible to say whether that particular branch had been so or not since the amalgamation, as the various businesses had been merged into one, as they could not be separated.

By **Mr. Pilling**: He considered that the business at Manchester was a larger one than that at Cadby Hall. A larger number of men were also employed at Manchester. The men at Cadby Hall were mostly boys.

Further examined by **Mr. Butcher**, **Witness** said that the directors of C. L. Baker and Co., Limited, were never anxious to amalgamate with the other companies, but, in view of the opposition which they would have had to face, it was considered advisable to do so. The names of responsible gentlemen appearing on the prospectus inspired him with confidence in the concern.

It was stated at this point of the enquiry that the minute-book of Woodhouse and Rawson, Limited, which it was supposed had been lost or destroyed had been found, and was at the disposal of the Official Receiver.

Mr. F. W. Pixley was next examined, and, in reply to the Official Receiver, stated that he had acted as auditor of Woodhouse and Rawson United, Limited, and of the Woodhouse and Rawson Electric Supply Company, Limited. Being on one occasion unable to obtain the necessary materials for the purpose of auditing the accounts of the latter company, his firm threatened to take further steps in the matter. That, however, might be looked upon as a figure of speech, because he was not aware of what further steps could be taken; it was a bark without a bite. He could not say whether that particular audit had ever been completed. In the prospectus of the Company it was stated that a profit of £21,000 had been made by Woodhouse and Rawson, Limited, in the previous year, but he did not certify to those profits—that was a matter which rested entirely with the directors. His certificate as auditor was accompanied by a report to the shareholders, and the certificate and the report ought to have been read together. In a book which he had written on the subject he expressed the opinion that the auditor's report ought to accompany the accounts which were issued to shareholders. He had since had occasion to modify that opinion owing to the difficulty of enforcing what he, as an auditor, might consider to be proper, and the book now quoted from was a very early edition of his work. The balance-sheet of October, 1890, exhibited a full and correct view of the Company's affairs, being founded upon the books of the Company. He even went beyond the books of the Company.

The **Official Receiver**; You were a "watch-dog" upon the directors?

Witness demurred to the term "watch-dog" as being altogether inappropriate. As auditor for the shareholders he considered it was his function to see that the transactions and accounts were as represented by the directors, and that there was nothing wrong about them at all, but he was in no sense a "watch-dog." As to the duty of an auditor, he might say that on one occasion he took upon himself to enlighten the shareholders, and the only acknowledgment he got for his trouble was his dismissal, because he was said to have exceeded his powers.

The **Official Receiver**: If you thought that it would be better for the shareholders not to know something, do you consider that you are justified in not telling them?

Witness: Yes, subject to certain qualifications.

Mr. Registrar Hood: What are they?

Witness said that there were numbers of trading companies now in existence in which it would be very disastrous for the public to know full particulars of their business transactions.

WEDNESDAY.

When the proceedings were resumed on Wednesday,

Mr. F. W. Pixley, an auditor of the Company, was recalled and further examined by the Official Receiver. He explained, with reference to his answers given on Tuesday, that he would not be acting rightly if he passed an account if there was anything in it which he knew was intended to mislead the shareholders of a company. He believed the shareholders of the United Company pur-

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chased the concern thinking it to be a flourishing industrial business, and he was aware that considerable losses were incurred in that branch of the Company.

The **Official Receiver**: Looking at these circumstances, do you now think it would have been better to have disclosed the information you obtained?

Witness said he did. He distinctly warned the directors not to pay a dividend. Questioned as to the profit included in the balance-sheet at June 30, 1890, witness said a sum of £30,000 was included as profit in respect of the International Okonite Company, Limited, which was incorporated within a week of the close of the financial year. The cheque for that amount was held over for a week and witness insisted upon its appearing under the head of "cheques and cash in hand." He was not aware that the United Company subsequently applied for £40,000 of shares in the Okonite Company. Counsel's opinion was taken as to the right of the directors to include a sum of £17,000 as profit over the promotion of the West Kensington Stores, Limited, and they were advised that the sum could be included In a letter to the Company witness suggested that the trading and promotion accounts should be kept separate, but after several interviews with Mr. F. L. Rawson he did not insist upon the suggestion being carried out. He could not say that throughout the Company's existence he had found that Mr. F. L. Rawson was ever anxious to run the profits up higher than they should have been. Mr. Rawson was entitled to one-fourth of the profits after payment of a dividend of 15 per cent., and, according to the balance-sheet for 1890, he became entitled to £13,000, which was placed to his credit. In December, 1889, the Company declared an interim dividend of 15 per cent., and witness wrote protesting against its payment, it being very unusual for a dividend of that kind to be paid without the accounts having been drawn up and properly audited. He did not see any prospectus beyond the first, and he thought he had raised objections to his name appearing. He had never held a single share in the Company. He did not now think that he was wise in being persuaded to give way on the question of separate accounts for the commercial branch and the promotion of companies' business. According to the agreement made with the vendor company, a sum of £75,000 was to be deposited as a dividend guarantee fund until July, 1892, towards ensuring the payment of a minimum dividend of 15 per cent. for that period. In January, 1891, a meeting of the shareholders was held, when it was resolved to return the guarantee fund, a rebate of £12,000 on the purchase-money being allowed. Witness was not communicated with by the directors, but had his advice been asked he should certainly have thought it unwise under the circumstances to recommend this course to the shareholders. With reference to the balance-sheet of 1891, witness said that the gross profit amounted to £74,568. He had no reason to doubt the fact that a considerable loss had been made in the industrial business during the year's trading. The "profits" included an item of £14,975 represented as profit in connection with the Phœnix Trust Company, Limited. He became aware that this company was one promoted by Baron Grant and Mr. F. L. Rawson. Witness was not satisfied with the information given to him, and wrote a letter to the Board with reference to the way in which the profits were made up, in which was enclosed the certificate he proposed to give. The certificate was in the following form:

"We have examined the accounts of this Company for the 13 months ending July 31, 1891, and certify that although they are practically correct as regards figures, yet they do not disclose the following facts to the shareholders. The gross profit referred to consists almost entire of profits made on financial and not commercial operations, and is produced almost exclusively by taking credit for values put upon shares in other companies promoted by this Company, which are subject to realisation. The investments, consisting of £118,453, are composed exclusively of those shares and of those of a private financial company working in connection with this Company, while the shares in one of these companies, valued at £35,145, are only the property of this Company by virtue of an agreement signed on July 31, 1891. The 'sundry debtors' include an amount of over £15,000 due from the managing director. Nothing has been written off the patents or the patent rights and charged against the profit and loss. That in our opinion the guarantee to the shareholders having been renounced at a special meeting convened for the purpose, no dividend should be paid in money until the investments referred to have been converted into cash."

The **Official Receiver**: If that certificate had been appended to the balance-sheet would it not have acquainted the shareholders with the state of affairs?

Witness: It would have done so.

The **Official Receiver**: Why was it not appended?

Witness: Because it was represented to me that it would damage the Company.

The **Official Receiver** stated that important documents, which ought to have been in the possession of the Company, or handed to the Official Receiver, were missing. They must have been removed by someone. It was remarkable that several documents of importance had been "spirited away."

Mr. F. L. Rawson disclaimed all knowledge and responsibility in the matter.

Continuing, **Mr. Pixley** said that the issue of the above certificate would have had a prejudicial effect upon the interests of the Company.

The **Official Receiver**: You will admit that it would not be a ground for withholding the information?

Witness said it would not. The market value of the shares would have been damaged by the certificate. He yielded to the representations made to him, and, subject to certain pledges made by the directors, the certificate was withdrawn. He had several interviews with Mr. F. L. Rawson, and perhaps he was "over-persuaded" He wished it to be borne in mind, however, that the Company had a substantial reserve fund, The goodwill was taken in the balance-sheet at £98,000, and he held the view, in spite of the fact that the industrial business was carried on at a loss, that the Company were justified in keeping the goodwill at the same amount they had paid for it. "Sundry investments" were returned at £119,000, and the statement of affairs now showed a depreciation of £69,000 on the shares held. At the meeting of the shareholders no mention was made of the loss on the industrial business, and witness did not explain anything about his certificate. With reference to the balance-sheet of July, 1892, witness considered it his duty to make a special report to the shareholders in consequence of the books not having been balanced, and because certain items in the accounts did not afford in themselves a sufficient explanation of the position of affairs. He reported that it was impossible for him to complete the audit, as the books had not been kept properly, and that he was unable to vouch the payments in consequence of the vouchers not having been properly arranged and because certain of them were missing. The item, "sundry investments," £109,413, consisted of shares in companies either promoted by, or allied with, the United Company, and he asserted that he was unable to express any opinion as to their value. He also discovered that some of the certificates for the shares were not in the possession of the Company in consequence of their never having been issued. He reported that the loss for the year appeared to be £122,198, even supposing that the securities and the sundry debts (£73,612) realised the amount taken credit for, and that he was unable to accept any responsibility for the value placed upon the assets. Against this loss there was a reserve of £35,000, and a balance carried forward from the previous year of £8,030.

In reply to **Mr. Jenkins**, the **Witness** said that he had no reason to doubt the honesty and integrity of any member of the Board, but, in his opinion, the accounts were not sufficiently amplified.

By the **Official Receiver**: He was not aware that his predecessor in Woodhouse and Rawson, Limited, had resigned his position because he complained that he was interfered with in making an audit. It was the first time he had heard such a suggestion.

The enquiry was adjourned until Wednesday next.—*The Times.*

BUSINESS NOTES.

Western and Brazilian Telegraph Company.—The receipts for the week ended June 15 were £2,379.

Liverpool Overhead Railway.—The traffic receipts of this railway for the week ended 17th inst. amounted to £882.

Wallsend.—Mr. W. Cathorne, the proprietor of a temporary theatre at Wallsend, proposes to erect a new permanent theatre to be lighted throughout by electricity.

West Ham.—As notified in our advertisement columns, the Council of the borough of West Ham invite tenders for the electric lighting of the public hall and free library.

Leeds.—Mr. Wilson Barrett will build a new theatre in Leeds which will be lighted by electricity. He has not yet settled upon a site, but the building is to be completed by April next.

Ayr.—The sub-committee of the Council who were empowered to select a proper site for electric light works, have been authorised to conclude negotiations without referring to the Council.

Accepted Tender.—The London County Council have accepted the tender of Messrs. Crossley Bros., Limited, for the supply and erection of three gas-engines at the Heathwall pumping station.

Walthamstow.—The Walthamstow Local Board have decided to take measures for the lighting of the district if the Lea Bridge Gas Company still decline to reduce the price they are charging.

Canvasser Wanted. — "British," of 50, Foregate-street, Worcester, requires a smart man, with a practical knowledge of electricity, for canvassing for wiring orders. Salary and commission are offered.

Dewsbury.—The Town Council have decided that the new chimney at the electric light station shall be octagonal, and of stone, at an additional cost, as compared with a brick one first proposed, of £100.

Dawson Gas-Engines Syndicate, Limited.—This Company has been registered with a capital of £70,000, in £10 shares, to acquire certain patents, the property of Henry T. Dawson, and to manufacture gas-engines.

Mansfield.—The tender of Messrs. Colomb and Co., London, for £123 for the erection of telephonic communication between the new waterworks and the manager's office, has been accepted by the Town Council.

Devonshire.—Application is to be made by the County Council to the Local Government Board for permission to borrow £8,000 in connection with the asylum, of which £6,000 is for the installation of the electric light.

South Staffordshire Tramways.—Mr. Justice Wright, sitting as an additional judge of the Chancery Division, last week dismissed the petition of Mr. Alfred Dawson and others for the winding up of this Company, the petitioners desiring to withdraw it.

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Milford (Ireland).—The entire electrical plant at Milford, co. Carlow, has been sold by the representatives of Messrs. J. E. H. Gordon and Co. to Major Alexander, who is putting down a new alternator to meet the increasing demand for current.

Interest Warrants.—The City of London Electric Lighting Company, Limited, give notice that the transfer books of the debenture stock of this Company will be closed from the 23rd to the 30th inst. for the purpose of preparing the interest warrants.

F. H. Royce and Co., Limited.—This Company has been registered, with a capital of £30,500, to purchase the business of F. H. Royce and Co., at Cooke-street, Hulme, Manchester, and to carry on the business of manufacturing electricians and mechanical engineers.

Bradford.—Mr. John Hart has been having the Theatre Royal fitted throughout with the electric light. Power is supplied by two 16-h.p. gas-engines. The auditorium will be lighted with one large central electrolier, the dress-circle, balcony, and stage having separate lights.

Southport.—The annual report of the Highway Committee of the Town Council states that the gas used during the year for the engine pumping was booked 61,600 in 488¼ hours, averaging 126 cubic feet, but for charging the electric launch, etc., only 251 hours had been booked.

Paying of Coupons.—The Anglo-Portuguese Telephone Company, Limited, notify that coupons No. 13 of the first mortgage and No. 8 of the second mortgage debentures of the company will be paid by Parr's Banking Company and the Alliance Bank, Limited, on and after the 2nd prox.

Appointment Open.—The Vestry of St. John, Hampstead, are about to appoint an electrical engineer to take charge of their electric light station. He must have actual practical experience of alternating-current central-station work. Further particulars are given in our advertisement columns.

Presentation.—The employés of the firm of Messrs. Peto and Radford, of Hatton-garden, presented Mr. William Peto on Tuesday last with a handsome silver salver, engraved with a suitable inscription, on the occasion of his marriage on June 21 to Miss Woodhead, of Newlands, near Huddersfield.

Ship-Lighting.—The ferry steamer "Birkenhead," which has been built to the order of the Birkenhead Corporation by Messrs. John Scott and Co., of Kinghorn, Scotland, has taken her trial trip. A complete installation of electric lighting has been provided by Messrs. J. H. Holmes and Co., of Newcastle.

City and South London Railway.—The receipts of the Company for the week ended June 17 were £831, against £782 for the same period last year, or an increase of £49. The total receipts for the first half-year of 1894 show an increase of £719 compared with those for the corresponding period of 1893.

Wolverhampton.—The Town Council have authorised the Lighting Committee to advertise for tenders for the execution of the necessary works and the provision of all fittings for the supply of electricity to the Town Hall, market hall, art gallery, and free library, and to submit the same to the Council for acceptance.

Dover.—The surveyor to the Town Council last week brought up a bill for £141 for work done and wages paid for the electric light company, and it was ordered to be presented. The Town Clerk explained that they had a deposit of £200 in hand, but as there was other work to do this sum would not come out of that.

Battersea Polytechnic Institute.—The following appointments are open for session commencing September next: demonstrator in mechanical engineering, demonstrator in chemistry, pupil teacher (male) in training in art department, mechanic in engineering workshop. Particulars may be obtained of the secretary.

Llandudno Electric Supply Company.—The Llandudno Electric Supply Company, Limited, was registered on Tuesday. The first directors are Dr. James Nicol, J.P., Dr. William Nicol, Messrs. R. Conway, C.C., J. Bellis, J. Smith (Craigside), W. Arnold, and W. Ellis-Jones. Mr. R. Bellis is the solicitor, and Mr. W. Kingsland engineer to the Company.

Manchester District.—Messrs. Drake and Gorham have obtained the contract for the lighting of the Consolidated Bank at Manchester with about 80 lights of 16 c.p. The current will be taken from the outside supply. This firm appears to be very busy in the Manchester district, where, it will be remembered, they opened a permanent branch some time back.

Edinburgh.—Arrangements have been made for laying the foundation-stone of the electric light station on Monday, 25th inst., at 4 o'clock. The Lord Provost, Sir J. A. Russell, will perform the ceremony. There will be a dinner in the Council-chamber afterwards, and later a popular lecture in the Albert Hall, at 8 o'clock, by Prof. Kennedy.

Loanda Gas Company, Limited.—This Company has been registered with a capital of £50,000, divided into 4,000 preference and 1,000 ordinary shares of £10 each, to acquire a concession granted by the Municipal Board of the city of Loanda, in South-West Africa, for public and private lighting in the city of Loanda by means of gas, electricity, or any other system.

Clerk of Works Required.—The Electric Lighting Committee of the city of Coventry invite applications for the post of clerk of works for the erection of the buildings of their central generating station. The salary offered is £4. 4s. a week. Applications, with copies of testimonials, to be delivered at the office of the town clerk, 40, Bayley-lane, Coventry, by the 23rd inst.

English and Colonial Electric Light Company, Limited.—This Company has been registered with a capital of £50,000 in £1 shares. The object is to carry into effect an agreement between S. W. Maquay of the one part, and J. S. Forbes of the other part, for the acquisition of certain patents and inventions connected with electricity, and to carry on business as electrical engineers.

Bishopsgate Institute.—The Bishopsgate Institute, one of the foundations created out of various City funds under the auspices of the Charity Commissioners, is to be lighted by electricity, from the specification of Mr. W. H. Trentham, M.I.M.E., 39, Victoria-street, S.W., who is consulting engineer for the work. The current will be taken from the City of London Supply Company's mains.

Extra Pay.—The Finance Committee of the London County Council, in order to expedite the preparation of the plans, specification, and estimates for the generating station to be constructed in connection with the electric lighting of the Victoria-embankment and Waterloo and Westminster bridges, authorised the engineer to employ some of his assistants after the usual office hours. These officials are to be remunerated for their extra work.

Gravesend.—The Town Council have intimated to the National Telephone Company, Limited, that the Council are prepared to enter into one indivisible contract for three years for a wire from the chief constable's residence to the police station, and a wire from the latter to the local exchange for £16 per annum, the Council reserving the right of an additional wire from the office of the mayor, town clerk, or other Corporation official at £4 per annum.

Hotel-Lighting.—The electric light throughout the Royal Palace Hotel, Kensington, to which we referred in a previous issue, is in harmony with the furnishing and decorations, and is carried out with great taste. The reception-rooms contain fine examples of burnished pendants, brackets and rosettes. The contract was entrusted to the Walsall Electrical Company, Walsall, and credit is due to them for carrying out the work in the short space of time allotted.

Lancashire Boilers Required.—The London County Council invite tenders for two new Lancashire boilers and fittings at the Council's Central Works, Belvedere-road, Lambeth, S.E. Persons desiring to submit tenders may inspect the drawings and obtain the specification, bills of quantities, form of tender, and other particulars at the Engineer's Department, County Hall, Spring-gardens, S.W., upon payment of £1. No tender will be received after Monday, July 2.

Buxton.—For the protection of the Duke of Devonshire, Lord Playfair will move on the third reading of the Buxton electric lighting provisional order that unless his Grace's consent is given it shall not be lawful to break up or interfere with the Crescent, Buxton, or the streets lying between the Crescent and the eastern corner, and the Old Hall Hotel and the junction of Spring-gardens and Terrace-road. Other amendments strengthening this clause are also proposed to be inserted.

Wisbech.—After the usual tender from the Wisbech Lighting Company for lighting the public streets had been accepted by the Town Council last week, the Mayor said the above was the only tender that had been received, but he had a communication which had only come to hand on the previous day from an eminent firm of electricians with a view to lighting the town by electricity. No tender had been sent in. Mr. Whitehead said he did not think they ought to entertain the communication if there was no tender.

Engineer Required.—The Commissioners for Public Baths and Wash-houses for the Parish of St. Saviour, Southwark, invite, by July 3, applications for the post of engineer, to take charge of the whole of the baths and wash-houses machinery, including the electric lighting plant. The salary offered is £2 per week, apartments, lighting, and coal. Particulars of the duties can be inspected and forms of application obtained at the office of Mr. Henry Langston, clerk to the Commissioners, 32, Borough High-street, Southwark, S E.

Nottingham Central Station.—Operations in connection with the new electric light works, situate in Wollaton-street, have been marked by rapid progress. The various buildings are in a forward stage, while the brickwork of the chimney, rising to an altitude of some 160ft., being completed, the work of fixing a cast-iron cap, weighing close upon 9½ tons, is now being finished. The task of raising and placing the cap in position was entrusted to Mr. W. G. Furse, of 17, Burton-street, who had to design and construct special tackle for the purpose.

Shoreditch.—The Electric Lighting Committee of the Shoreditch Vestry reported, at a meeting of the latter last week, that they had considered the draft contract for the purchase of the Pitfield-street site for £33,500 for the erection of an electric lighting station, public baths, dust destructor, etc., and they recommended that the contract be approved, and that upon a formal contract from the Library Commissioners to take their agreed portion of the site being entered into, the seal of the Vestry be attached thereto. The Vestry ultimately decided to purchase the property.

Aberdeen.—At a meeting of the Watching and Lighting Committee of the Town Council it was agreed to light the new police buildings by electricity at a cost of £250. It was at first intended to light the building by gas, and piping for that purpose was laid down. In consequence, however, of the decision to use electricity, gas fittings will be unnecessary, and on these a saving on the original contract of £100 will be made, so that the net extra cost of introducing the electric light will be £150. Trinity Hall, which belongs to the seven incorporated trades of the city, is being extended at a cost of about £8,000, and will be lighted throughout by electricity. The architects are Messrs. Brown and Watts.

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Edison and Swan Company.—Notice is given that an extraordinary general meeting of the Edison and Swan United Electric Light Company, Limited, will be held at the Cannon-street Hotel on Tuesday, July 3, at a quarter past 12 o'clock in the afternoon, to consider and, if approved, to pass the following resolution—viz., "That the provisional agreement dated June 5, 1894, submitted to this meeting and expressed to be made between the Swan United Electric Light Company, Limited, and this Company for a sale of the Swan Company's undertaking to this Company for debenture stock of this Company be, and the same is hereby, approved."

New Installations in Liverpool.—The Northern Electrical and Ventilating Company, of 3, Smithfield-street, Tithebarn-street, Liverpool, are making great strides in Liverpool and surrounding districts. They have just completed the lighting of the elaborate new offices and warehouse of Messrs. Boyd and Grant, the well-known provision merchants, of Liverpool and America, and have also taken the contract for lighting the adjoining building. In addition to these, the company are ventilating the new Cunard works and Messrs. Clarke and Son's tobacco factory, to say nothing of the other important contracts they now have in hand. The company are to be congratulated on such a record at the close of the first year of their establishment.

Moss Side.—At the last meeting of the Local Board, Mr. Marr, of the Collier-Marr Electric Lighting Company, submitted a proposal for the electric lighting of some of the leading thoroughfares of the district. He said that in place of 156 of the gas lamps now in use the company proposed to fix electric lights of 36 c.p. in 49 of them, and lights of 16 c.p. in 56 others. In addition, it was suggested there should be four arc lights at four points of the district. This would give a total illuminating power of 10,626 candles, against the present illuminating power of 2,026 candles, and the company would undertake to provide this at a cost of £533 per annum. Mr. Marr was requested to submit his proposal in writing, and this he promised to do.

Electric Lighting of Glasgow.—At a meeting of the Watching and Lighting Committee, Bailie Primrose, the convener, on behalf of the sub-committee in connection with the proposed lighting by electricity of certain additional streets of the city, reported that they would not feel warranted in recommending that the scheme be gone into, the cost showing such an increase on the present system of lighting. They recommended, however, by way of experiment, that 12 incandescent gas lamps should be erected in St. Vincent-street, between Buchanan-street and Renfield-street. From experiments made by Mr. Hamilton, the superintendent of lighting, within the last month, it was believed that the present lighting would be vastly improved by these lamps without extra cost. It is proposed to reduce the price of current to private consumers from 7d. to 6d. per unit.

The Derby Exhibition.—The exhibitors at this exhibition, with a number of friends, dined together recently at the County Hotel. Amongst those present were Messrs. Crowther, J. E. Stewart (engineer of the electric light station), H. Baker, Lineham, Fellows, Maxwell, Covington, Myers, Windham, Seward, Fryer, Roberts, and Rull. Mr. J. E. Stewart occupied the chair. After full justice had been done to an excellent repast, an enjoyable evening was spent. In replying to the toast of the evening—"The Mayor, Corporation, and Electric Lighting Committee"—Mr. Stewart said that he was pleased to have heard that many of the exhibitors had booked some very good orders. Considering that the whole of the firms exhibiting might be considered rivals in trade, a spirit of good feeling and friendliness had existed during the whole of the time that the exhibition had been open.

New Electric Vehicle.—Messrs. Taylor, Cooper, and Bednell, of Coventry, have just completed the construction of a vehicle propelled by electricity, the invention of Messrs. Blumfield and Garrad. The car has the appearance of a small wagonette with seats for four. It runs on four pneumatic-tyred wheels, with bearings. The frame, which is carried on springs, is constructed of weldless steel tubing similar to that used in the manufacture of cycles. The current is stored in 24 cells, 12 beneath each of the two seats, and is conducted to a motor underneath the vehicle. The motor is nominally of 1 h.p., capable of rising to 2 h.p. for a short time in case of necessity, and communicates its power to the rear axle by means of differential speed gear and chain. A speed of from 3½ to 13 miles an hour is said to be attainable. A trial has been made, the car being taken to Birmingham, a distance of 18 miles, and an average of eight miles an hour is stated to have been attained.

Plymouth.—At a meeting of the Borough Council on Monday the Special Purposes Committee reported the receipt of a report from the town clerk with regard to the Plymouth, etc., Gas Bill He stated that in accordance with the resolution of the committee of March 21 last a petition was lodged against the Bill. One of the points of the petition was that the company should not be at liberty to apply for powers to supply electricity. The company's counsel abandoned the provisions of the Bill relating to electricity so far as the borough of Plymouth or the outside area, the subject of the borough extension proceedings, is concerned. In the discussion which took place on the subject of the Bill, Mr. J T. Bond pointed out that the Corporation was now alone endowed with the power to proceed with the electric lighting of Plymouth. Mr. Bellamy said that gas was probably about to be superseded by electricity, which was coming to the front by leaps and bounds. It was ultimately decided not to take action for the acquisition of the gasworks by the Corporation.

Weston-super-Mare.—The Electric Lighting Committee of the Town Commissioners considered on the 2nd inst. letters from Messrs. E. C. De Segundo, Mr. Douglas C. Bate, Mr. F. W. Ball, and Mr. G. F. Metzger, offering their services to the Board. Mr. Harvey proposed that the committee should not select an electrical engineer that day, but that they advertise and offer a premium of 50 guineas for the best plans, specifications, and report, and that the same be sent under a motto. No one seconded the proposition, and Mr. Deverell thereupon moved, and Mr. Boyden seconded, "That Mr. Medhurst's offer to report fully and to advise the committee on the questions of electric lighting, and tramways, and on the utilisation of dust destructors for the production of electric power, at a fee of 50 guineas and personal out-of-pocket expenses connected with visits to Weston, be accepted, it being distinctly understood that the Board does not commit itself to Mr. Medhurst for anything further than this first stage, and shall be at liberty to appoint any other engineer afterwards, if so disposed. If employed to carry out any or either of the works, the 50 guineas before mentioned to be merged in Mr. Medhurst's commission." The proposition was carried, Mr. Harvey alone dissenting. The clerk was instructed to prepare and forward Mr. Medhurst the necessary contract. When these minutes were brought up last week for confirmation, Mr. Masters said that the engineer selected should have been Mr. Hammond. The Clerk pointed out that the committee had been given the power of selection. After further discussion, the minutes were confirmed.

Coventry.—The Electric Light Committee of the City Council have received tenders for the erection of the buildings of the electric light station in Sandy-lane, as follows: Messrs. Foster and Dickson, Rugby, £9,090; Mr. Charles Garlick, Coventry, £7,860; Mr. John Bowen, Birmingham, £7,742; Messrs. Liggins and Strong, Coventry, £7,534. 12s.; Messrs. T. and H. Herbert, Leicester, £7,382; Messrs. G. F. Smith and Sons, Leamington, £7,138; and Mr. C. G. Hill, Coventry, £6,829. The Council have accepted the tender of Mr. C. G. Hill. A clerk of the works is advertised for at a salary of four guineas per week. The site of the works adjoins the premises of the cotton company, and is bounded by the Coventry Canal, and there is also a siding from the L. and N. W. Railway. The buildings to be erected will cover only a portion of the ground, ample room being left for any extensions and additions that may be required in the future. Messrs. G. and I. Steane are the architects, and Mr. Robert Hammond is the consulting engineer. Included in the buildings to be erected will be an engine-house, boiler-house, coal-stores, and pump-room, together with the usual offices. The system which has been adopted for the incandescent lighting is the alternating-current high-tension converter system. There will be 2,176 yards of cables, run, on one side only, through the following streets in the proportions named: Broadgate 80 yards, Smithford-street 317, Fleet-street 125, High-street 117, Earl-street 173, Jordan-well 153, Hertford-street 276, Cross-cheaping 187, Burges 183, Hay-lane 167, Priory-row 228, and Bayley-lane 270. A letter has been received from the Local Government Board sanctioning the raising of a loan of £20,000 for the purposes of electric lighting.

Lighting of Bedford.—The Electric Light Committee of the Town Council recommended last week that application should be made to the Local Government Board for sanction to the borrowing of £12,000 for the purpose of providing the necessary buildings, machinery, and plant for supplying electrical energy within the borough, in accordance with the plans and estimates prepared by Mr. F. H. Medhurst, M.I.E.E. Mr. Richards, in proposing the adoption of the report, said that the committee had obtained an interview with Sir Hugh Owen, of the Local Government Board, and they received the advice to apply for a loan of £12,000, instead of £10,200, in order to meet emergencies that might arise, and if found necessary to increase the area. It was thought desirable that the authority should know their present position financially, and he might say that the balance of their outstanding loans was £25,000. This would require a rate for the next two half years of 6½d. in the £. At the end of that time their rate would be reduced, with regard to the outstanding loans, to 3½d. A £12,000 loan for 30 years would be met by a rate of 1d. in the £ each half-year, so that they would have reduced their liability by a 3½d. rate, and increased it by a 1d. rate. But they must remember also that they hoped to get a return of this money from the use of the light in the town, and the committee on that ground had felt that there was no responsibility in the matter. Besides, it was almost impossible for them to go wrong, for their plans were first overhauled by the engineers, and afterwards by the Local Government Board. It was certain that they could obtain the £12,000 loan at 3½ per cent., and they hoped to get it at 3 per cent. Mr. Geoffrey Howard seconded, and the report was adopted.

Beverley.—A motion was submitted by Mr. Whiteing to the Town Council last week that a committee should be appointed for the purpose of investigating the process now adopted in other towns for the production of steam power from town refuse, and that such committee should report the result of their investigations. The Livet system, which was in operation in Halifax, appeared to be most satisfactory. He was informed that every description of refuse could be consumed, and estimating the amount which would be available in the borough, he believed they could produce by this system as much steam as would be raised by 1,500 tons of steam coal; but for the purpose of his argument he would put it at 1,200 or 1,300 tons. The question then arose, what could they do with this power? They used power at the outfall works which cost them £40 a year in gas, while they paid Mr. Palmer between £80 and £90 a year to remove the refuse. The whole of this, he held, might be saved. For a town the size of Beverley the plant for utilising this refuse would be about £1,000 or £1,100, which, if borrowed for 50 years, would cost

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about £46 per annum, or if for 30 years a little over £65. He had shown how £120 at least could be saved, while if they procured a stone-breaking machine the reduction of expenditure would approach £250. They could use this fuel at the baths, and, if deemed necessary, they could, by getting a dynamo, introduce electric lighting. He had no particular scheme to advocate; all he asked at present was for the appointment of a committee who would investigate and report upon the adaptability of the system to Beverley. Mr. Norton seconded the motion. Mr. Chilman said it would be a waste of time to enquire into the scheme when it was in such a stage that no place could pronounce it satisfactory. The Mayor said that two years ago a gentleman sent him a lot of papers on this subject, but he (the mayor) could see no advantage to Beverley by adopting such a system. Mr. Whiteing, in reply, said he was advocating no scheme, and the committee could incur no expense; all he asked for was a committee to enquire into the subject. The motion was lost by one vote.

Results of Tenders.—The following tenders were received by the Paddington Board of Guardians for the electric lighting of the female wards of Paddington Infirmary, according to the specification of Mr. A. W. Sclater, A.M.I.C.E.:

H. Thorpe	£284	15	0
Benham and Sons, Limited	235	0	0
P. Jones	214	0	0
Harrison, Coles, and Co.	210	0	0
E. P. Allan and Co.	184	5	0
Laing, Wharton, and Down	182	11	0
W. Mackie	176	0	0
W. Andreas and Co.	175	0	0
F. G. Howard	175	0	0
Vaughan and Brown	174	0	0
Girdlestone and Tatham	173	15	0
Strode and Co.	167	0	0
H. F. Joel and Co.	159	0	0
Newton and Co.	159	0	0
D. Bate	156	0	0
Fenton and Barnes	153	0	0
J. W. Carpenter, Limited	146	13	0
Lund Bros.	146	0	0
Crompton and Co.	143	0	0
Hulett and Co.	142	15	0
Russell and Co.	139	0	0
Dawson, Hammond, and Co.	135	0	0
Roger Dawson, Limited	132	0	0
Jarvis and Berry	128	10	0
Peto and Radford	125	0	0
Wenham and Waters	122	10	0
Pritchett and Gold	122	10	0
Sotheby and Ridout	109	10	0
New and Mayne	107	0	0
Spagnoletti and Crookes	101	13	0

Yarmouth.—At a meeting of the Town Council, the Electric Lighting Committee presented the following report: "The borough surveyor stated it would now be necessary to provide an overhead travelling crane for the engine, the cost of which had been provided in the estimates. He had ascertained that the cost of a new crane with rails and fixing would be £163, and he had been offered a second-hand crane at Birkenhead for £38, and two others at Gloucester for £35 and £50 each, which with fixing and new girders would cost £92 against £163 for a new crane. The committee instructed him to inspect the cranes, and, if suitable, purchase the best of the second-hand cranes, and to take the necessary steps to fix it, so that it should be in place for Messrs. Crompton to fix their machinery with. The surveyor was further instructed to interview Mr. Preece to ascertain whether it would not be possible to obtain the water for condensing purposes from a well or wells on the Denes instead of from the river. He was directed to obtain tenders for any necessary pipes, and to carry out such other works as might be necessary to obtain a supply of water for the condensing plant, provided that such works did not exceed the amount of the estimates. The surveyor stated that it was now necessary the Council should fix the rate of charge for a supply of electricity to private consumers, and also the rules upon which such supply could be obtained, and he submitted the rules adopted in Bradford, Hull, St. Pancras, and Dublin. The committee instructed the surveyor to confer with Mr. Preece, and submit a set of rules with Mr. Preece's recommendation as to what the charge should be. The town clerk stated that the question of improving the lighting of Gorleston had been referred by the Council to the Electric lighting Committee. The surveyor stated that he had no doubt but that Gorleston could be as well lighted by electricity as by gas for the same amount now paid for gas lighting, and he recommended that the matter should stand over for the present until the electric lighting works had been at work some time, to see if the whole of their plant was not in use for Yarmouth. If it were not, the lighting of Gorleston might be proceeded with. The committee resolved to recommend the Council to allow the matter to stand over for the present." Mr. Ruddock moved, "That immediately after the electric lighting works are started in Yarmouth, the surveyor report on the lighting of Gorleston and Southtown by electricity." Mr. Press, who seconded this, said if Gorleston and Southtown had to wait until it was ascertained whether the whole power of the plant would be absorbed by Yarmouth, there would be an indefinite delay. When the gas bills came in they took one's appetite away altogether. Mr. Ruddock's proposition was agreed to. The several other recommendations made by the committee were adopted. The surveyor presented a lengthy report on the question of the Livet system of generating steam through the destruction by combustion of town refuse. He had visited several towns to see the system in operation, and his conclusions were—"The system has, in my opinion, not yet had sufficient trial to warrant me advising you to adopt it in any way at present. I recommend that you adopt a policy of watching other people's experiments, which will cost you nothing."

Larne.—At a meeting of the Town Commissioners held on Tuesday, the Chairman stated that in accordance with the instructions of the Board he, with their clerk, waited upon Mr. J. W. M'Ninch, solicitor, who had written to Messrs. J. E. H. Gordon and Co., Limited, the electrical contractors, on the subjects raised at their last meeting, and the clerk had since received a reply from Mr. Norris, receiver and manager. The clerk then read two letters from Mr. Norris, in which he stated he would agree to the insertion of Clause 3 in the agreement, which is with reference to the erection of new lamps at the company's expense. The Board then proceeded to discuss a motion by Mr. Fullerton, which proposed that they should light at dusk instead of at sunset. A number of members expressed the opinion that the company should exercise some discretion, and that on a dark, foggy evening in winter they should light rather earlier than usual, while on a clear evening the lighting might be delayed for some time. The clerk read a letter on this subject from Mr. Turner, resident engineer to the company, who appended a time-table of the hours at which he proposed they should light. Mr. Turner afterwards appeared before the Board, and said that his reason for proposing that they should adopt this table was to avoid complaints. With reference to the proposal by some of the Commissioners that they should light earlier on dark evenings and later on clear evenings, the difficulty was that the advantage would be all the one way; if they lighted at a later hour than that laid down in the table there were certain to be complaints, and the Commissioners also had the advantage if the hours of lighting were earlier on dark evenings. Mr. Turner having left the Board-room, Mr. Fullerton altered his motion to read: "That former resolutions and decisions of the Board fixing the time of lighting public lamps as from sunset be rescinded, and that 'dusk' be the time for lighting in future, and that dusk be understood and explained as by table submitted per Mr. Turner." This motion was passed unanimously. It was then agreed that the agreement between the Larne Town Commissioners and Messrs. J. E. H. Gordon and Co., Limited, electrical engineers, with reference to the contract for public lighting of the town of Larne for the next three years be completed, seeing that Mr. Norris, receiver and manager, has agreed to the insertion of Clause 3 therein.

Electric Lighting of Cardiff.—In the course of a communication to a Cardiff paper Mr. Sydney F. Walker says: "About a week ago appeared a letter from Mr. Coles, an electrical engineer, of Swansea, pointing out that lamps were now obtainable taking a smaller current than those commonly in use, and, therefore, costing less to run, and Mr. Coles went on to draw the inference that the cost of the electric light in Cardiff, when using these lamps, at the price of 6d. per unit, would be only slightly in excess of the cost of gas. Mr. Coles forgot to mention that if lamps are used which, being worked at a higher state of incandescence, do not require as much current to furnish their normal 16 c.p. on any given supply service, the life of the lamps themselves is very considerably reduced; so that the actual cost of the light is very slightly reduced, if at all. As the manufacture of these higher incandescent lamps improves, the cost of lighting will steadily decrease. In fact, the improvement in the manufacture of the lamps is one of the sources from which decreased cost in the future will be obtained. At the present time, however, the facts are exactly as stated in your leader which preceded Mr. Coles's letter—for the same candle-power and the same time, the electric light will cost approximately double that of gas; but considerable economy may be effected in the lamps burnt in rooms not constantly in use, by turning them on when entering the room and turning them off on leaving it. There will also be considerable economy in the cost of interior decorations, and in particular of curtains and similar fabrics. While I am on the subject may I once more urge upon the Corporation the advisability of adopting the large incandescent lamp, in place of the arc, for street-lighting? It is not yet too late. The lamp-posts will answer quite as well, if clear glass be substituted for the obscured glass now fixed in them, for the large incandescent lamps as for the arcs, while the adoption of the large incandescent lamp will save money and will save the Council many a bad quarter of an hour. The reasons which induced many engineers to so strongly favour the arc lamp are fast disappearing. It appears to be more than doubtful if the much-vaunted "rectifier" will even produce a current that will work an arc lamp properly, and this 18 months after it was supposed to be so perfect and so well known that only an ignoramus would have questioned the advisability of its adoption. And if the rectifier is abandoned, as it undoubtedly will be, half the reasons for the use of the arc are gone, since the light given by the arc furnished by an alternating current is only half as powerful as that given by an arc furnished by a continuous current in the direction in which it is required. And if we take from the remaining half the percentage of the light rays absorbed by the obscured glass, the difference between what is left and the light given by the large incandescent lamp absorbing the same energy will be, if anything, in favour of the large incandescent lamp. In London, and everywhere else, too, the large incandescent lamp is steadily supplanting the arc. Where, two years ago, the former was not to be seen anywhere, now it is seen side by side with its rival, and steadily gaining ground. The "rectifier" is the last fence. Let Cardiff county councillors go for it boldly, and they will find safe and

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easy riding on the other side." A meeting of the Lighting and Electrical Committee of the Cardiff Corporation was held at the Town Hall on Monday under the presidency of Alderman Carey. The meeting was called for the purpose of making a preliminary selection of candidates for the positions of engine fitters at the new electric lighting station. There were 136 applications for the four appointments, the salary offered being £2. 2s. a week Mr. Riches asked whether it was intended that any of these fitters should do repairs to the electrical plant. The Chairman replied in the negative, and explained that they would simply look after the driving engines and effect any repairs that were necessary from time to time. They would work a system of eight hours' shifts, with a spare hand in case of emergency. Ten candidates were selected for submission to a future meeting of the committee, when the appointments will be made. A meeting of the Lighting and Electrical Committee of the Cardiff County Council was held at the Town Hall on Tuesday, under the presidency of Alderman Carey. Mr. Massey reported that with the exception of a few yards of piping in Working-street the whole of the mains were laid for the electric lighting cables. One large engine had been delivered, and one large and two small dynamos had been erected. All the dynamos had arrived, and the second large engine was on the way. The erection of the engine had been stopped pending the appointment of the four engine fitters. When they had been appointed there would be at least a month's work for them in the engine-house.

PROVISIONAL PATENTS, 1894.

JUNE 11.

11276. **Improvements in and relating to electric incandescent lamps.** Rudolf Langhans, 61, Fore-street, London.

11280. **Improvements in jointing electric conductors.** William Geipel, 49, Kidbrook Park-road, Blackheath, London.

11286 **Improvements in electric arc lamps.** Henry Capel Lofft Holden, Royal Arsenal, Woolwich.

11312. **Improvements in electric accumulators or secondary batteries.** Henry Harris Lake, 45, Southampton-buildings, Chancery-lane, London. (La Société Electro-génique, France.)

11320. **Improvements relating to telegraphic and telephonic transmission.** Henry Harris Lake, 45, Southampton-buildings, Chancery-lane, London. (Michael I. Pupin, United States.) (Complete specification.)

11323. **Improvements in apparatus for the automatic transmission of signals through telegraph lines and cables.** Alexander Muirhead and Angus Fraser, 124, Chancery-lane, London.

11338. **System of electric signalling.** Charles Molyneux Houghton, Gayton, Cheltenham. (Louis F. C. Rich, United States.)

JUNE 12.

11364. **Improvements in dynamo-electric machines.** William Lowrie, 152, Stroud Green-road, Finsbury Park, London.

11418. **Improvements in telephone transmitters.** John Edward Kingsbury, 24, Southampton-buildings, Chancery-lane, London. (The Western Electric Company, United States.) (Complete specification.)

JUNE 13.

11439. **Improved electric indicator.** Henry John Wagg, 40, Bryanston-square, London.

11452. **Improvements in connectors for conductors used with electrical apparatus.** Rookes Evelyn Bell Crompton and Herbert John Dowsing, 55, Chancery-lane, London.

11483. **Improvements relating to the generation of electricity.** John Evelyn Liardet, 9, Warwick-court, Gray's-inn, London.

JUNE 14.

11559. **Improvements in magneto-electric motors.** Henry Lüdeke, Ernst Louis August Lüdeke, Arthur James Thorman, Ernest de Bunsen, and Edward Madge Hore, 4, St. Benet-place, Gracechurch-street, London.

11587. **Improvements in the process of and apparatus for the electrolytic decomposition of solutions and for the immediate separation therefrom of the liquid or dissolved electrolytic products.** Léon Paul Hulin, 53, Chancery-lane, London. (Date applied for under Patents, etc , Act, 1883, sec. 103, November 25, 1893, being date of application in France.)

11601. **Improvements in printing telegraph instruments.** Oscar Lillian Kleber, 45, Southampton-buildings, Chancery-lane, London. (Complete specification.)

JUNE 15.

11606. **Improvements in separators for electric storage cells.** F. R. Davenport, 1, Granville-road, Eastbourne.

11613. **An electrical minnow for fishing purposes.** Henry Wren Rowland, 3, Regent-road, Crosby, Liverpool.

11628. **Improvements in the mode of and means for suspending electric lamps, lanterns, shades, and other such articles.** Frank Hewitt, 77, Colmore-row, Birmingham.

JUNE 16.

11684. **Improvements in and connected with electrical safety fuses.** Alexander Marr, 70, Market-street, Manchester,

11701. **Improvements in electric fire-alarms.** George Richard Neilson and Alfred Charles Brown, 50, Old Broad-street, London.

11713. **Improvements in or connected with telephones.** John Goulding, 12, Basinghall-street, London.

SPECIFICATIONS PUBLISHED.

1891.

18597. **Electrolysis.** Andreoli. (Second edition.)

1892.

11624. **Coin-operated telephone apparatus.** Lake. (Noriega.) (Second edition.)

14056. **Electric motors.** Lake. (Stanley and another). (Second edition.)

23805. **Arc lamps.** Bombe. (Second edition.)

1893.

1229. **Secondary batteries.** Lloyd. (Second edition.)

4106. **Secondary battery plates.** Epstein.

10398. **Electrical communication with vessels or buoys.** Lenox.

10441. **Conduit electric railway.** Hughes. (De Voe.)

10569. **Regulating the temperature of electrical heating, etc., apparatus.** Crompton and Dowsing.

10584. **Electrolytic apparatus.** Castner. (Second edition.)

11426. **Electric motor.** Todd and Lewis.

12153. **Measuring, etc., electric currents.** Waterhouse.

12362. **Marking meat by electricity.** Armstrong and others.

12523. **Electric brushes, etc.** Wollaston.

13336. **Electrolytic production of nickel, etc.** Hoepfner.

13412. **Electric generators.** Conrady.

14091. **Electric fuses.** Brain.

14202. **Dynamo-electric generators and motors.** Pyke and Harris.

1894.

139. **Telephone exchange systems.** Callender.

5663. **Cut-offs for gas, electric, etc., conduits.** Kleine and Lindner.

6742. **Electric switch.** Siemens Bros. and Co., Limited, and Grimston.

8149. **Electrical measuring instruments.** Lake. (Van Vleck and another.)

COMPANIES' STOCK AND SHARE LIST.

Name.	Paid.	Price Wednesday.
Birmingham Electric Supply Company	5	5¼-5⅝
Bournemouth Electric Company	—	—
Brighton and Hove Company Original	100	210-215
—— "A" Ordinary	—	160-164
Brush Company, Ordinary	3	2⅞-3
—— Nom. Cum , 6 per cent. Pref.	2	2⅛-2⅜
—— 4½ Debenture Stock	100	109-112
Charing Cross and Strand	5	4⅞-5⅛
Chatham and Rochester	—	—
Chelsea Electricity Company	—	—
City of London, Ordinary	10	12-13
—— 6 per cent. Cumulative Pref.	10	13½-14
—— 5 per cent. Debenture Stock	75	87-90
City and South London Railway, Consolidated Ordinary	100	36-38
—— Debenture Stock	100	119-121
—— 5 per cent. Pref. Shares	10	12½-13
Crompton and Co., 7 per cent. Cum. Pref. Shares	5	3⅞-4¼
—— 5 per cent. First Mortgage Debentures—1-400 of £100 and A, 1-200 of £50	100	95-100
Elmore's French Company	2	1⅛-1⅜
Electric Construction, Limited	2	1⅛-1⅜
—— 7 per cent. Cumulative Pref.	2	1½-1⅝
Elmore's Copper Depositing	2	1½-1⅝
Electricity Supply Company for Spain	5	—
Elmore's Wire Company	2	1-1⅛
Fowler-Waring Cables	5	1-1⅛
W. T. Henley's Telegraph Works, Ordinary	10	6⅞-7⅛
House-to-House Company	5	1-1⅛
India Rubber and Gutta Percha Works	10	23½-24½
—— 4½ per cent. Debentures	100	103-105
International Okonite, Ordinary	10	1-2
Kensington and Knightsbridge	5	4⅞-5⅛
Liverpool Electric Supply, Ordinary	5	6⅛-6⅜
—— Pref.	4½	5⅞-6⅛
Liverpool Overhead Railway	10	8 3/16-8 5/16
—— Pref.	10	12⅝-12⅞
—— 4 per cent. Mortgage Debentures of £100	100	112-114
London Electric	5	⅞-1⅛
Metropolitan Electric Supply	10	8⅞-9
—— 5 per cent. Reg. Debentures, 1-10,000 in Bonds of £10, £20, and £40	—	107-110
National Telephone, Ordinary	5	5-5⅛
—— 6 per cent. Cum. First Pref.	10	15-16
—— 6 per cent. Cum. Second Pref.	10	14⅛-15⅛
—— 5 per cent. Nom. Cum. Third Pref.	5	5⅛-5⅜
—— 4½ per cent. Deb. Stock	—	113-115
Notting Hill Company	10	4⅛-5⅛
Oriental and Electric Company, £1 shares	1	1-1⅛
—— £5 Shares	—	5⅛-5⅜
Southampton Electric Company	—	—
St. James's and Pall Mall, Ordinary	5	7-7⅛
—— 7 per cent. Pref.	5	8⅛-8⅜
Swan United	8½	8-8⅛
Telegraph Construction and Maintenance	12	39-41
—— 5 per cent. Bonds	100	104-107
Westminster Electric Supply, Ordinary	5	6⅛-6⅜
Yorkshire House-to-House	4½	4⅛-4⅜

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NOTES.

Telephony in Germany.—Greifswald and Stralsund are to be telephonically connected.

Exhibition at Kiel.—A German national exhibition is to be held at Kiel from August 4 to 19.

Central Station at Donaueschingen. — Messrs. Schuckert and Co., of Nuremberg, will carry out this installation.

Electric Lighting at Munich.—An electric installation is being put up for the lighting of the Central and Rangir railway stations.

Telephony at Gera.—A movement is on foot for the establishment of telephonic communication between Gera, Zeitz, Weissenfels, Halle, and Berlin.

Electric Lighting at Combourg.—M. Corvaiser is projecting an electric light installation for this town in Ille-et-Vilaine. It has 6,000 inhabitants.

Internationale Elektricitats-Gesellschaft.—This Viennese Company has declared a dividend of 6 per cent., after allowing for depreciation, reserve, etc.

Kashmir Telegraphs.—Arrangements are in progress to incorporate the Kashmir State Post and Telegraph Office with the Imperial Posts and Telegraphs.

Alarming Intelligence.—Extract from an electrical contemporary, June 21, 1894: "This is the last number of —— which will be published . . . . ."

Konigsberg Tramways.—The Union Electricity Works will take over the systems of the Königsberg Horse Tramway Company not later than May 1, 1895.

Electric Lighting at Madras.—A proposal is now before the Government of India for lighting with electricity the Presidency post and telegraph offices in Madras.

Lundy Cable.—The cable was tested on Friday, and found perfectly sound at the island end. It was reported some time ago that the cable was wearing at that point.

Mining Institute of Scotland.—At the last meeting of this society a further discussion took place on Mr. J. T. Forgie's paper on "Electric Haulage Plant at Dumbreck Colliery."

Electric Lighting at Ancenis.—The Municipality are in course of making arrangements with a company for the establishment of a central electric lighting station in the town.

Mr. Edison.—It is announced, according to one news agency, that Mr. T. A. Edison is ill owing to overwork. According to another, however, he has hurt himself by falling down some steps.

The Pneuelectric Carriage.—This is the name which has been given to the electric vehicle devised by Messrs. C. R. Garrard and T. W. Blumfield, which we described in our "Business Notes" last week.

Price Down at Altona.—Messrs. Schuckert and Co. announce that the price of current will be reduced at Altona by about 6 per cent. owing to the fact that there are now nearly 10,000 lamps connected.

Electric Traction in Hamburg.—All the formalities have now been gone through in connection with the projected high-level electric railway between Hamburg and Altona, to which we have previously referred.

Berlin-Vienna Telephone. — Work in connection with the telephone line between Berlin and Vienna, which is to be ready by November, is being pushed forward. The charge to be made is 4s. for three minutes' conversation.

Messrs. Schuckert and Co.—The net profit made for the year 1893-94 by the Elektricitäts-Aktiengesellschaft vorm. Schuckert and Co., of Nuremberg, is £105,196. The directors recommend the payment of a dividend of 9 per cent.

Lighting at Budapest.—The National Theatre has hitherto been lighted by an electric plant of its own, but the Minister of the Interior has given instructions for it to be connected with the mains of the Hungarian Electricity Company.

An Advantage.—Among the advantages set forward on behalf of the Olympic Music Hall, which is to be put up to auction to-day, is the fact that the buildings are fitted throughout with a duplicate system both of electric and gas lighting.

A Funny Electrician.—The hero of Mr. J. M. Barrie's play, "The Professor's Love Story," which has been produced this week by Mr. E. S. Willard at the Comedy Theatre, is a gentleman who studies electricity, and when he falls in love does not know it, but takes medical advice to obtain a cure.

Brunswick.—The Brunswick Street Tramway Company are negotiating for the substitution of electric for horse traction on their lines. The firms who have the matter in hand are the Allgemeine Elektricitäts Gesellschaft of Berlin, Messrs. Siemens and Halske, and Messrs. Schuckert and Co.

Tramway Traction.—The Tramways Committee of the Leeds Corporation are somewhat perplexed in regard to the future working of the Leeds tramways, and they have this week visited Newcastle and Edinburgh with a view to obtain definite information. In Edinburgh the cable line will be inspected. What about electric traction?

Chambery.—Messrs. Thivel and Bravais are pushing forward the works in connection with the utilisation of the power of the Granier Falls. The quantity of water is not great, but a head of 2,000ft. is available which will yield 13,000 h.p. to 14,000 h.p. After providing for current for the electric lighting of Chambéry and intermediate localities, there will be power remaining for other purposes.

The Dodge Repeated.—Evidently the *Financial Times* has not read the note in our last issue entitled "An Advertising Dodge," as it continues to publish news from the *Cable Gazette* about the plague in Hong-Kong. Is it possible that the Broad-street cable clique has found other means futile, and has acquired an interest in "absolutely trustworthy" so as to advertise the *Cable Gazette*?

Electric Underground Railway for Vienna.—The Anglo Bank, in conjunction with Messrs. Siemens and Halske, are applying for a concession for an electric railway between the Ferdinand Bridge and Penzing. The line would be about 3½ miles long. It would be carried underground for a certain distance *viâ* Stefansplatz, Graben, and Opernring, but at the Penzing end would be a street tramway.

Glasgow Tramways.—Next week the Corporation will assume the responsibility of working the city tramways. They do not at the moment seem inclined to go in for electric traction, but they appear to be open to progress in a small way, for although to begin with oil will be used for illuminating purposes, the lamps have been constructed in such a way that they will be suitable for electric light should it be adopted.

Telegraphs in Kashmir.—The telegraphic party in Kashmir under Mr. Olphert's superintendence have crossed the passes and recommenced work, says an Indian contem-

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porary, but the whole party suffered severely from snow blindness as fresh snows have fallen. They are now recovering, however. Telegraphic communication has been reopened with Gilgit *vid* Kashmir. The unfinished line of last year was but little damaged.

The Transvaal.—According to a German contemporary, Messrs. Siemens and Halske propose to erect at Witwatersrand, in the Transvaal, a central electricity station in order to supply the mines with electrically-transmitted power for small machinery, such as pumps and drills. Both water and steam power will be employed. A local agent of the firm has distributed circulars with respect to the project among mining concerns, and it is said that the scheme is likely to receive general support.

Lighting Refrigerating Premises.—In a paper read at the recent meeting of the Incorporated Association of Municipal and County Engineers, on "The Refrigerating Lifting, and Haulage Machinery, Electric Light Installation, and Cold Stores of Messrs. Nelson Bros., Commercial-road, Lambeth," it was mentioned that the electric current is generated by two low-speed Paterson and Cooper dynamos, coupled direct to two of Gwynne's high-speed double-acting engines. There are 1,600 incandescent lamps in different parts of the stores.

Telegraphy in Asia.—M. Venukoff has been giving the Société de Géographie some particulars respecting the establishment of the telegraph in Asia. The Chinese have opened telegraphic communication between Pekin and Kashgar. One of the first telegrams sent from the latter place to the Chinese capital was one from the Russian consul-general. It consisted of 18 English words, and the cost was about 3s. 9d. The distance is about 2,400 miles. It is proposed to establish a telegraph line, 200 miles in length, between Kashgar and Och in Russian Turkestan, so as to have a new line of telegraphic communication across Asia.

Society of Arts Conversazione.—At the invitation of the council of the Society of Arts, about 3,000 ladies and gentlemen were present at a conversazione at the Imperial Institute on Friday evening last. Sir Richard Webster, Q.C., M.P. (chairman), Sir Frederick Bramwell, F.R.S. (deputy-chairman), and the other members of the council received the company in the vestibule. The principal galleries of the institute were thrown open to the guests, including those containing the collections illustrating the natural resources of the colonies and India, and the exhibition of British artistic and decorative pottery, china, and glass.

Lighthouse Communication.—Materials have been dispatched from Kirkwall by the steamer "Fawn" to the Fair Isle, which lies midway between Orkney and Shetland, to be used in connection with the scheme for instituting telegraphic communication between lighthouses and the coasts. A telephone line is to be constructed from the lighthouse to the south of the island, so that in the event of shipwreck, the news may be promptly forwarded from the one place to the other. At present there is a lifeboat at the south end of Fair Isle, and it is hoped that by means of the telephone the rescue service in case of shipwreck will be made much more efficient than at present.

Northern Society of Electrical Engineers.—On Saturday last a party, consisting of about 40 members, paid a visit to Liverpool. They were received at the Oldham-place station of the Liverpool Electric Supply Company by Mr. A. Bromley Holmes, C.E., who explained all the points of interest. The members subsequently visited the overhead electric railway and inspected the generating station, permission having been given by Mr. S. B. Cottrell, the engineer for the company. The party then proceeded to the National Telephone Company's new switch-room, where the system was explained. This is the first of a series of excursions to be made during the summer, the next one being to Antwerp on July 20.

Personal.—Mr. B. J. Diplock has been appointed secretary of the Fowler-Waring Cables Company, Limited, *vice* Mr. D. Stephen, who resumes his duties as accountant of the company. Mr. James Tiddy, late manager of the Central and South American Telegraph Company, has been appointed electrician-in-charge of the testing-rooms of the Fowler-Waring Cables Company, Limited, at North Woolwich. It is sometimes said that the services of electricians are ignored by the lay Press, but at last electrical merit has been recognised, for *Ally Sloper* has not only published a portrait of Captain Ronald Scott, but also conferred upon him the diploma of F.O.S., while he is referred to as the English Edison. Mr. Edison has now cause to hold his head up.

The Underground.—We referred to this railway last week, and made certain suggestions. Mr. Weir, M.P., is apparently much troubled about this matter, but he will be Weiry—we mean weary—before he finds it comfortable to travel by this line. On Friday last, in the House of Commons, he asked the President of the Board of Trade whether his attention had been drawn to certain articles and correspondence as to the state of the atmosphere in the underground railway, and the means of purifying it; and whether he would take steps to deal with the matter effectually. Mr. Bryce said he had himself experienced the state of the atmosphere in the underground railway, but Parliament had not entrusted the Board of Trade with any powers to enable the Department to deal effectively with the mischief.

Electrical Exhibition at Budapest.—On the 10th inst. there was opened at Budapest by the Hungarian Minister of Commerce an exhibition of electrically-driven machines, to which we have referred on previous occasions. This exhibition has been carried through by the Ministry of Commerce on the initiative of the Commercial Museum, the object being to demonstrate to the public the importance of electricity for power purposes. There are 22 Hungarian and 23 foreign exhibitors, who are represented by over 200 machines of various kinds. Current is obtained from the street mains of the Hungarian Electricity Company, who furnish it free. Messrs. Ganz and Co. have also furnished the electric motors gratuitously, as have Messrs. Siemens and Halske part of the fittings. Exhibitors have obtained their space without any charge whatever.

Electric Launches.—A representative of an evening paper has held an interview with Earl Russell on the subject of launches on the Thames. When asked whether he preferred an electric launch, his lordship is reported to have replied: "Not at all. Mine is a steam launch. Electric launches are all very well for those who like to potter about up and down two or three reaches. You can do more with steam, and are independent of charging stations, and can go where there are none—up canals, for instance. Wherever you are you can get coal of some sort. You have the bother of keeping an engineer, but in the case of electric launches the accumulators run up the weight and the expense, involving, I should think, an annual outlay of 20 per cent. of their first cost. If you have an engineer who can do odd jobs, £5 will cover the cost of ordinary repairs on a steam launch. However, in either case the expense is laying up the boat in the winter, and getting her into commission again. Unfortunately, a number of steam launch owners know nothing

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about their working, nor do their so-called engineers." Asked as to whether he had tried oil launches, Earl Russell replied in the negative, adding that he had smelt them.

National Boiler Insurance Company.—We have received the report for 1893 of the chief engineer of the National Boiler and General Insurance Company, of Manchester, which contains much information of value to steam users. There were 20 formal investigations under the Boiler Explosions Act last year, and general particulars are given of the finding of the Court in each case. Altogether 27 actual explosions were reported, the vertical boiler, as usual, heading the list. The inspectors met with a very large number of defects arising from external corrosion. Wasting of this nature has been one of the principal causes of explosions, and during the last 10 years 63 explosions of steam-boilers have occurred which are directly attributable to weakening caused by external wasting. Details, with illustrations, are given of the explosion of a vertical boiler owing to over-pressure; of a water-tube boiler owing to accumulation of deposit; of a vertical multitubular boiler owing to external corrosion; and of a vertical boiler owing to restricted head room, which prevented the safety-valve operating.

Electrolytic Decompesition of Water.—M. Le Blanc, in a paper published in a German periodical, upholds the view of the primary decomposition of water, and replies to the objections brought forward by Arrhenius. The increase in the electrolytic decomposition of water by the addition of an electrolyte is explained, not by an increase in the degree of dissociation of the water, but in the capability of ion formation. He also explains the fact that hydrogen is not immediately liberated during the electrolysis of an alkali salt with a mercury cathode, by stating that the potassium ions give up their electricity to the mercury more readily than the hydrogen ions. That hydrogen ions are present in water is shown also by the fact that potassium reacts readily with water and not with paraffin. In the case of solution of various metallic cyanides in potassium cyanides, he points out that cadmium is easily separable, but platinum scarcely so, which is hard to explain on a secondary decomposition hypothesis, unless the electro-deposited platinum were soluble in potassium cyanide; this, however, he proves experimentally is not the case. He finally points out that the primary decomposition theory has the advantage of simplicity.

Observations on the Nature of Phosphorescence. Mr. Herbert Jackson, in a paper read before the Chemical Society, dealt first with the readiness with which the phenomena of phosphorescence may be studied by using a mechanical pump capable of very rapidly giving high vacua (Fleuss's pump). The author considers that in many cases the phosphorescence cannot be ascribed to impurities, but that a presumably pure substance yields in several instances phosphorescence of different colours. The main portion of the paper is occupied with an attempt to show that the phenomena of fluorescence, phosphorescence in air on exposure to light, and phosphorescence of substances in a vacuum under the influence of the electric discharge, are of the same nature—viz., a response on the part of the substances to the operation of radiant energy propagated after the manner of light in undulations of short length. These undulations proceed from the electrode, and to them the gas in the tube responds, giving rise to the visible light in the gas. To this light some phosphorescent bodies respond, but others require to be affected by the very short undulations to which air is opaque. Such substances therefore only phosphoresce in high vacua. These conclusions are based on experiments made with a "jar spark" in air acting upon phosphorescent substances placed in the appropriate foci of a quartz lens; on the study of the behaviour of such substances outside a vacuum tube provided with a quartz window, and also on their behaviour inside the vacuum tube. The results of a very large number of experiments seem to indicate a close connection between the phenomena of phosphorescence of air and in a vacuum, broken only when the opacity of quartz to some undulations and of air to others interferes.

Electric Lighting in Calcutta.—Owing to a combination of favourable circumstances, not the least of which are its comparative cheapness, its immunity from accidents, and the reduced rates at which insurance companies will accept risks on factories, mills, etc., where electricity is used as a luminant power, electric lighting has acquired great popularity and is making rapid progress towards its general adoption in the near future for such purposes, says the *Indian Engineer*. We are therefore glad to notice two instances in which the installation has been successfully carried out. One is at the Calcutta Flour Mills Company, Limited, Narkaldanga, and consists of one 2½ nominal horse-power vertical Hornsby engine, which has a separate steam supply from either or both of the boilers. This engine drives a Crompton compound dynamo of a capacity of 758 lamps. A switch is provided on each floor of the mill and in each room in the bungalow. The wiring is carried out with Henley's cable, having an insulation resistance of 2,000 megohms per mile. The second installation has been carried out by the Oriental Telephone and Electric Company, Limited. This company opened an electric light department in Calcutta some three months ago, and this is their first installation. It has been carried out at the roller flour mills of Messrs. A. C. Mookerjee a Narkaldanga. The dynamo, a 60-light machine, is run from a countershaft, and is fixed on the first floor of the mill inside a small dust-proof room, in which are also fixed the switchboard, testing instruments, etc. This company are about to move into new premises now being built. They also intend putting down a special plant for the repairing of electrical machinery, cables, etc., and will have a dynamo running for the charging of accumulators, testing other dynamos, motors, etc.

The Government and Telepheny.—We referred to this matter last week in our "Notes," and in connection therewith Captain Bagot, in the House of Commons, has asked the Postmaster-General whether an agreement between the Post Office and the National Telephone Company had been in preparation for two years, and whether, in view of the fact that he had stated on various occasions during the last year that the agreement would be shortly laid before the House of Commons, he could now state definitely before what date the agreement would be produced. The hon. member further asked the right hon. gentleman whether he was aware that the effect of the long delay in concluding the agreement and the refusal of the Post Office in the meantime to grant licenses to municipalities had been to enable the National Telephone Company to increase their monopoly and place themselves in a better position than those municipalities which wish to obtain licenses, and whether he would state how many applications for local licenses from municipalities had been received since it was decided to purchase the trunk lines. Mr. A. C. Morton had a similar question on the paper. Mr. Henniker Heaton asked whether the Postmaster-General would take care that any agreement between himself and the National Telephone Company should provide that in the event of the purchase by the State of the company's property only the market value of the stock and plant actually belonging to the company should be paid as consideration money,

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without taking into account prospective profits, or any claim for goodwill, or any similar claim. Mr. A. Morley said: "Since I answered a question on this subject on April 30 last further points of considerable complexity have arisen in connection with the settlement of the details of the agreement. While I very much regret the delay which has occurred—a delay which is in no respect due to any absence of effort on my part to bring it to a successful conclusion—I cannot think that it has enabled the National Telephone Company either to increase their monopoly or to place themselves in a better position. In fact, the hon. member for the Southern Division of Westmoreland appears to forget that the National Telephone Company only enjoy a temporary license which terminates in 1911, and that every month that passes must therefore have the effect of reducing the value of their goodwill in the business. I hope the hon. member will not press me to answer the latter part of his question, as I do not think it would be desirable in the public interest to reply to it at the present moment. With reference to the question of the hon. member for Canterbury, I must point out that the agreement now being negotiated is simply intended to give effect to the arrangement made by the late Government for the purchase of the company's trunk wires—an arrangement which did not contemplate any interference with the general conditions of the expiring license."

North of England Institute of Mining Engineers. On Friday last the members visited Greenside Mines, Patterdale, where they were received by Mr. W. H. Borlase, who read a paper, giving the history and description of the Greenside silver-lead mine, in which the process of working was described, and the author mentioned that some time ago more power was required, and the question arose of compressed air *versus* electricity. Electricity was decided upon, and a turbine dynamo station erected. The water for the turbine is taken at an elevation of 1,750ft. above sea-level, and flows through an open watercourse, 1¼ miles in length, to a wooden tank, from which it is conveyed down the hillside for a distance of 1,080ft. in cast-iron pipes 15in. in diameter. The fall at the station is equivalent to a vertical head of 400ft., and the effective horse-power is about 200. The electric current is conveyed by two bare copper conductors on poles for three-fourths of a mile, while it enters the mine at an elevation of 1,600ft. above sea-level. The conductors from this point are insulated and covered with lead. About three-fourths of a mile into the mine, and down through No. 1 shaft, or 1½ miles from the dynamo, a 9-h.p. series-wound motor is worked, winding the stuff from a pair of sinkers. Further into the mine another quarter of a mile, and down through No. 2 shaft to the 360ft. level or bottom of the mine, is fixed another 9-h.p. motor, working a three-throw pump forcing the whole of the water in the mine below the Lucy Tongue level up to that level 360ft. high. About midway between No. 1 and No. 2 shafts is fixed a transformer, which reduces the pressure from 600 volts to 250 volts for the purpose of working an electric locomotive in the lowest day-level through which runs the water used by the two hydraulic engines. The locomotive runs with a train of 12 wagons, the total weight when loaded being 18 tons (exclusive of itself), and it does the work with the greatest ease over gradients in places of as much as 1 in 20 and in 24. The conductors in this day-level are phosphor bronze wire, and the current is fed to the locomotive by four contact pulleys. The difficulties encountered in fixing this plant and wiring the level can only be appreciated by the practical miner. The curves are so numerous that the train occupies three and four of them at a time in places. The gauge of the railway is 22in., width of locomotive 32in. over all, and height 46in. The engine-rooms, caging stations at the different levels, and shaft tops are lighted by six 100-volt 16-c.p. lamps, wired in series. The adoption of electric power has enabled the mine to be worked with six horses less underground, and effected considerable saving in other ways. The cost of maintenance since December, 1891, including accidental breakages and wearing, renewals, brushes, etc., has not exceeded £25, which speaks for itself when taking into account that no professional electrician is employed on the staff. The turbine dynamo station and offices outside are in communication with the chief stations inside the mine by telephone.

The Niagara Power Scheme.—A representative of the *Pall Mall Gazette* has interviewed Prof. G. Forbes in regard to the Niagara scheme for the electrical transmission of power. The professor stated that the company hope to have the electrical plant in operation by August or September. The only thing they are waiting for is the completion of the long vertical shaft, and when that is put into position the dynamos will be laid down. The pit for the turbines is 150ft. long, 40ft. wide, and 200ft. deep. At the bottom of this three turbines have been placed in position, each of 5,000 h.p. The power company have limited themselves in their charter to 200,000 h.p. on the American side, and are prepared, when the demand arises, to sink a second tunnel; but they are already occupied with plans, drawn up by Prof. Unwin, for developing a power station on the Canadian side of the river which might be got up to 250,000 h.p. This will be connected electrically with the station just completed, and the two will be able to serve a very large district. The distance included in the company's radius of influence depends on the electric pressure used, and on the way the conductors are laid. For 100 miles round they will be able, the professor stated, to supply power cheaper than it can possibly be produced by steam. In Buffalo, 15 miles away, where they expect to find the bulk of their demand at first, and where coal is extremely cheap—something like 1½dol. a ton—the cost of electrical transmission from Niagara in enormously less. The industries of Buffalo, at the present time, absorb about 60,000 h.p., and of this 10,000 h.p. is required by the electric lighting and electric street-car companies, both of which, he observed, will be their customers. There had been a considerable demand for power in advance. The Niagara Falls Paper Mills—the largest in the world—are taking water power from the canal and discharging into the company's tunnel; the Pittsburg Reduction Company, who hold the sole rights in America for the electrical preparation of aluminium, will be very large users of the supply. There are any number of millowners waiting to set up works as soon as the scheme starts, and requests for power come in from places as far distant as Albany — 350 miles away on the Hudson River. With regard to the alternators, it was stated that "these alternators are the outcome of an enormous amount of experiment and enquiry; they were made to my plans by the Westinghouse Company, of America. The important feature about them is their being simple, two-phase alternators." Dealing with the question of pressure, it was mentioned that the company will generate energy at 2,000 volts, and supply in the neighbourhood at that pressure, using transformers at the different works, if necessary. For distant transmission they have erected a transformer-house across the canal, connected by a solid masonry bridge and covered way, where they will transform the pressure to something like 10,000 volts. The works will have cost altogether by the time the supply begins from £600,000 to £800,000.

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ELECTRIC LIGHT AND TRACTION BEFORE THE ASSOCIATION OF MUNICIPAL ENGINEERS.

THE ANNUAL MEETING.

The Association of Municipal and County Engineers celebrated its coming of age last week in the hall of the Institution of Civil Engineers, where the first gathering of the society took place 21 years ago. There are now some 600 members belonging to the association, and a large number was present at the assembly on Thursday, Friday, and Saturday last.

Mr. A. M. FOWLER (the new president), in the course of his inaugural address, said: The great benefits which have recently accrued from the time and thought given by business men in town councils to municipal matters, has resulted in corporations rearranging their stock and borrowing capital for lengthy periods, in some cases for as long as 60 years, at the rate of, in many cases, under 3 per cent., and also by making the stock negotiable. These debts have not been entirely incurred directly for sanitary works proper, although the money is being expended with a view to the improvement of the public health, as in the case of acquiring waterworks, gasworks, tramways, hydraulic power, electric lighting, etc. All such undertakings, which formerly were in the hands of private companies, may now be said to be transferred to municipal authorities, and show in the capital account substantial assets, whilst the benefits derived by the ratepayers are considerable, not only on the ground of convenience and public health, but also more economical. In fact, the profits on gas, water, and tramways in some towns go far to pay the cost of public improvements: as in the case of Salford, which, during the time I acted as engineer, by laying down the tramways in pursuance of its own parliamentary powers, obtained a rental of 10¼ per cent., whilst Newcastle, in like manner, obtained 6¼ per cent., the only obligation being to keep the road in repair; whilst the new paving, sometimes of granite, was included in the capital account on which the interest was charged, thus bringing in many thousands of pounds per annum. Many towns have availed themselves of the powers offered by Parliament for providing electric lighting, and this is fast coming into universal adoption for private houses, the only drawback at present being the expense in providing the necessary motive power to bring it in closer competition with the cost of gaslight. This is, however, being daily reduced for small concerns by the introduction of Dowson's gas-engines and plant, and the application of anthracite coal, which is less costly than ordinary coal gas. This plant has now been running engines for some time with an expenditure of not more than 1¼lb. of fuel per indicated horse-power. Oil-engines are now also worked at a fraction less than one halfpenny per hour per horse-power. It is with hope, therefore, that the motive power for working dynamos may at no distant date be reduced in cost.

Among the various papers presented were two dealing with electric lighting and electric traction. The first is given below:

The Bradford Corporation Electricity Supply, with the Results of Four Years' Working.

BY JAMES N. SHOOLBRED, B.A., M.I.C.E.

It is just 15 years since, at the annual meeting of this association in 1879, the author had the privilege of reading his paper on "Electric Lighting and its Application to Public Illumination by Municipal and other Bodies." Appended to that paper was the Parliamentary "Report," then just issued, "of the Select Committee of the House of Commons upon Lighting by Electricity"; the first of that series of enquiries by both Houses of Parliament on the subject of electrical energy, and which was presided over by the late Right Hon. Edward Stanhope. Much progress, indeed almost beyond expectation, has been made during the past 15 years in the science, as well as in the application, of electricity to industrial purposes. One short extract from the report of the above-named committee will suffice to show this: "Your committee, however, are not in a position to make recommendations for conditions, which may hereafter ar but at present do not exist, as to the distribution of elec currents for lighting private houses from a central source o power. . . But at the present time your committee do no consider that any further specific recommendation is necessar than that the local authorities should have full powers to use the electric light for purposes of public illumination, and that the Legislature should show its willingness, when the demand arises, to give all reasonable powers for the ful development of electricity as a source of power and light."

The answer to these remarks may be said to rest, and very appropriately so, in the paper which is about to be read to the Association of Municipal Engineers. For, on behalf of those local authorities to whom the Legislature had been willing "to give all reasonable powers for the full development of electricity as a source of power and light," it says: "The demand which the committee foresaw having arisen, and the Legislature having entrusted us with the desired powers, it therefore behoves us to present you with the actual results of the first four years' working of the pioneer of our municipal undertakings—that of the Corporation of Bradford—and to whom all honour is due to the lead which they have taken in this matter." This period at Bradford it will readily be understood by the meeting treats of a most important time, of early trials, and of much anxiety for those upon whom the responsibility lay. It also represents a completed term in itself; being the first chapter, that of the two-wire period, in the history of the Bradford electricity works. With the current year the second chapter, that of the three-wire system, has commenced, this latter development, as well as others still to follow, having been foreseen and duly provided for at the time when the installation was originally laid down, as was pointed out to the Corporation about 12 months ago by Lord Kelvin, P.R.S., when considering the entire question of the supply of electrical energy, and when further stating that they had acted rightly in adopting the present system at the commencement of their undertaking.

The supply of electrical energy (continuous current at low pressure), inaugurated on September 20, 1889, was intended for all purposes to which the continuous current is applicable—such as light, power (including tramways), and the many chemical and other industrial applications which occur in a manufacturing town like Bradford. The supply was confined at first to the central portion of the borough—where are to be found the best shops, some hotels, and other large buildings, such as the Town Hall, the public markets, theatres, and other places of entertainment. The district supplied extends chiefly to the north and to the west of the central generating station in Bolton-road, to a distance in each direction of three-quarters of a mile. The electrical energy is distributed by means of underground armoured cables, laid in the ground itself, chiefly under the footwalks on each side of the street, without the intervention of any culvert, and with the connecting and other junction boxes filled up solid; thus avoiding any chances of accumulations of water or of gases such as, in other towns, have of late led to several serious accidents. From the central station a series of feeding mains, radiating in different directions, deliver the current to the distributing network, where it is maintained at a uniform pressure of 115 volts; a "standard pressure," which is found to adapt itself very fairly to the various applications of a town supply of electrical energy. The following steam generating and electrical plant has been erected at the central station; four steel Lancashire boilers, each of 180 h.p., working at 140lb. steam pressure per square inch. The steam-engines, compound, non-condensing, are of the inverted vertical type, each engine driving directly a dynamo, which is placed on the same bed-plate with it. All the engines are of the single-acting, closed Willans type; with one exception, which is of the ordinary double-acting marine engine class. This last was obtained at the commencement, but as the subsequent comparative working of the two types of engine showed that the closed type was better suited to the requirements of this station, all the later engines have been of the last named single-acting make. The total power of the steam-engines is about 1,600 i.h.p.; and the engines occur in the following sizes—viz., 80 i.h.p., 150 i.h.p., and 300 i.h.p. It should be noted that it is by the judicious use

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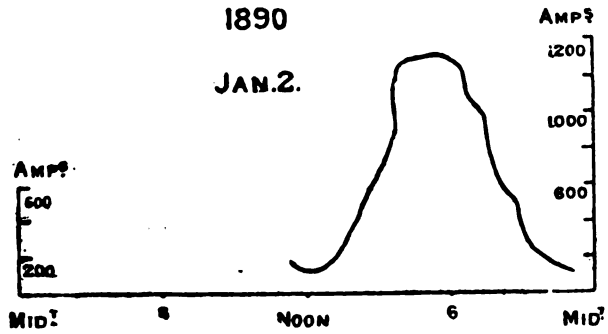
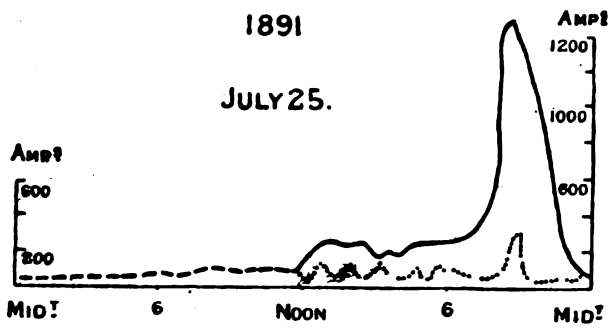
of several different sizes of engine, that the difficulty of meeting the great, and sometimes sudden, changes in the demand for steam power which occur in a supply of artificial illumination, can be successfully and economically got over. It seems almost needless here to point out the advantage of having the dynamos directly driven by the steam-engines, as against having belts or ropes intervening between them, especially after the clear statements as to the losses of the latter arrangement in Mr. R. E. Crompton's paper on the "Cost of Electrical Energy," communicated to the Institution of Electrical Engineers, and in the discussion thereon. The dynamos are shunt wound, and their total ampere output available at the consumers' terminals is about 5,000 amperes. A very valuable adjunct to this generating plant during the last three years has been a set of storage cells of Crompton-Howell make, which, though only of a moderate capacity, has rendered most important assistance in carrying on the supply uninterruptedly through



Ampere Output Curve.



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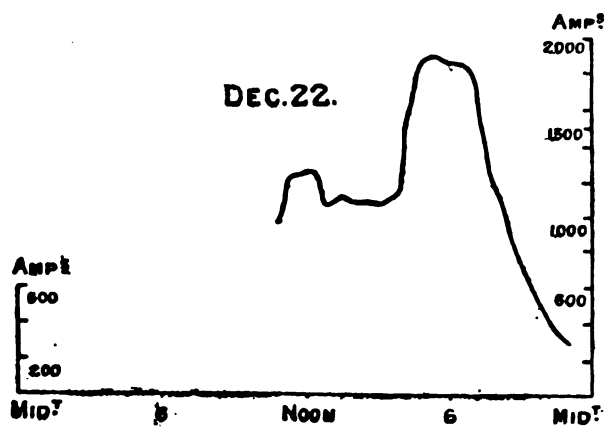

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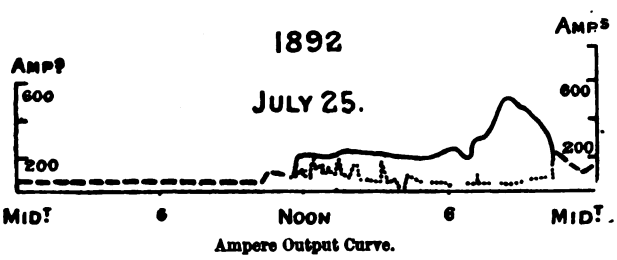

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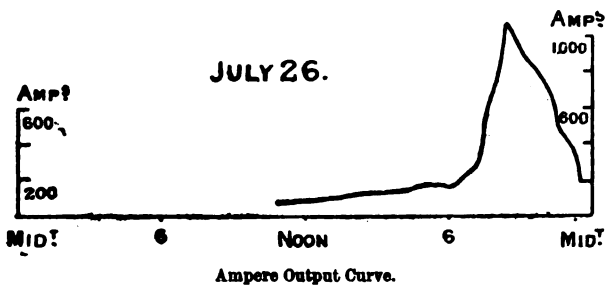

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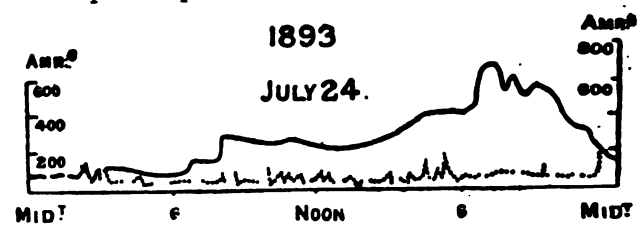

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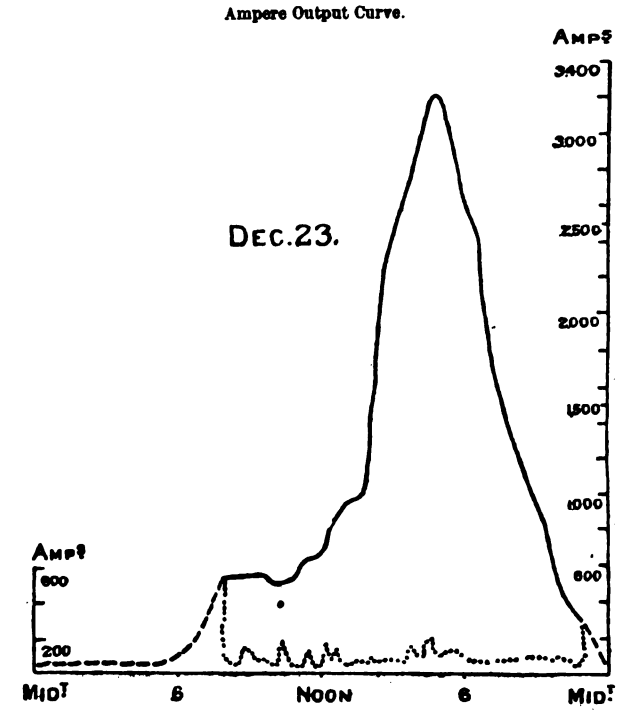

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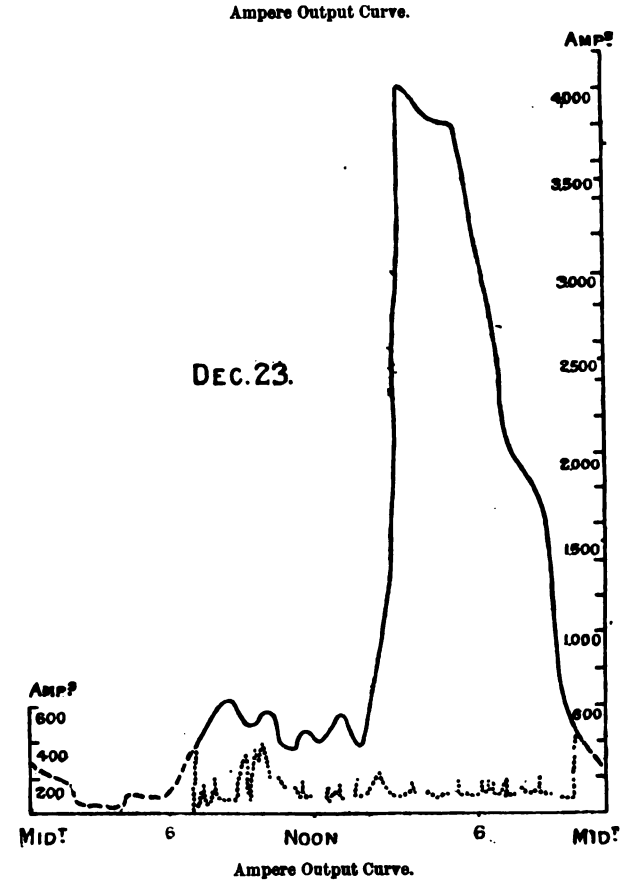

Ampere Output Curve.

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HALF-YEARLY REVENUE ACCOUNT.

Working expenses.	1890. June 30. £ s. d.	1890. Dec. 31. £ s. d.	1891. June 30. £ s. d.	1891. Dec. 31. £ s. d.	1892. June 30. £ s. d.	1892. Dec. 31. £ s. d.	1893. June 30. £ s. d.	1893. Dec. 31. £ s. d.
Salaries and wages	367 16 8	410 17 10	418 14 3	506 15 4	639 15 10	665 9 11 / 391 8 8	970 4 0	1,136 4 9
Coal	246 17 11	247 0 6	292 18 6	342 7 0	334 2 0	375 16 6	486 0 1	845 0 3
Water	33 16 4	34 0 0	34 15 6	36 19 0	38 12 0	57 7 8	62 4 8	66 9 9
Repairs and miscellaneous	100 11 6	204 13 3	272 7 9	431 1 8	297 8 5	532 4 2	406 10 7	335 7 6
Rent of land	83 18 1	83 18 1	83 18 1	83 18 1	83 18 1	83 18 1	83 18 1	83 18 1
Rates and taxes	46 0 0	104 6 6	67 1 8	69 11 6	112 4 9	101 2 1	133 7 11	145 16 3
Bank interest and commissions	19 1 4	89 14 9	95 9 7	120 7 5	108 2 11	104 1 6	111 1 5	139 11 4
Total working expenses	£898 1 10	1,174 10 11	1,261 5 4	1,591 0 0	1,614 4 0	2,311 8 7	2,253 6 9	2,752 7 5
Balance	-39 7 0	377 18 10	832 8 2	2,001 1 0	1,601 12 11	2,386 14 11	2,294 1 6	2,882 7 3
Total gross receipts	£858 14 10	£1,552 9 9	£2,093 13 6	£3,592 1 0	£3,215 16 11	£4,698 3 6	£4,578 4 3	£5,634 14 8
Units sold	39,113	68,794	85,103	154,258	141,622	223,789	207,650	272,964

INTEREST AND SINKING FUND ACCOUNT.

Payments.	1889. Dec. 31. £ s. d.	1890. June 30. £ s. d.	1890. Dec. 31. £ s. d.	1891. June 30. £ s. d.	1891. Dec. 31. £ s. d.	1892. June 30. £ s. d.	1892. Dec. 31. £ s. d.	1893. June 30. £ s. d.	1893. Dec. 31. £ s. d.
Interest on loans	467 7 5	360 9 11	360 14 0	469 16 10	545 0 6	636 18 5	719 11 3	771 11 8	785 17 5
Sinking fund	421 13 4	332 10 0	332 10 0	392 16 8	392 16 8	577 7 4	577 7 4	827 19 0	827 19 0
	£889 0 9	£692 19 11	£693 4 0	£862 13 6	£937 17 2	£1,214 5 9	£1,296 18 7	£1,599 10 8	£1,613 16 5

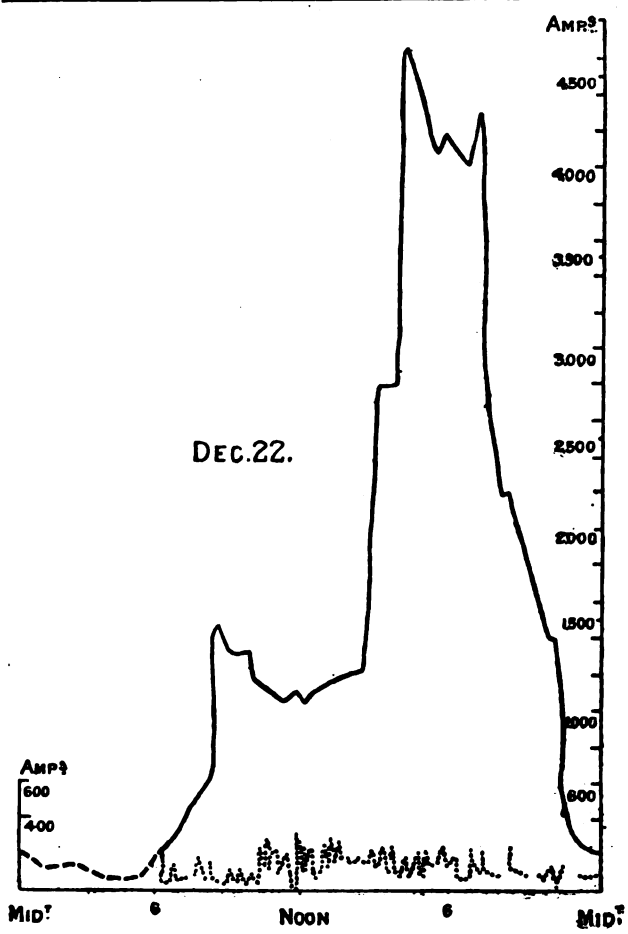
CAPITAL EXPENDITURE ACCOUNT.

1889. to Dec. 31. £ s. d.	1890 to June 30. £ s. d.	1890 to Dec. 31. £ s. d.	1891 to June 30. £ s. d.	1891 to Dec. 31. £ s. d.	1892 to June 30. £ s. d.	1892 to Dec. 31. £ s. d.	1893 to June 30. £ s. d.	1893 to Dec. 31. £ s. d.
18,456 2 4	25,223 19 11	27,209 4 8	35,370 7 11	40,224 19 10	45,136 8 6	48,568 12 11	52,309 2 4	56,591 1 2

PROFIT AND LOSS ACCOUNT.

	£ s. d.
1889. Dec. 31.—To debit of revenue	1,079 8 5
1890. June 30.—To loss on half-year	732 6 11
1890. Dec. 31.—To loss on half-year	315 6 0
1891. June 30.—To loss on half-year	30 5 4
By balance	290 11 7½
	£2,447 18 3½

	£ s. d.
1891. Dec. 31.—By profit on half-year	971 4 10
1892. June 30.—By profit on half-year	387 7 2
1892. Dec. 31.—By profit on half-year	1,089 6 3½
	£2,447 18 3½
1893. By balance from 1892	290 11 7½
1893. June 30.—By profit on half-year	625 16 10½
1893. Dec. 31.—By profit on half-year	1,179 1 0



Ampere Output Curve.

the 24 hours. The time during which the generating plant was enabled to be stopped, and the supply carried on unaided by the storage battery, amounted, out of the 24 hours, in 1891, on an average to 12 hours, or 50 per cent., and in 1892, to 10½ hours, or about 45 per cent.; while in 1893, owing to the increasing demands, it was only five hours, or about 21 per cent. of the entire time.

The importance of the economy thus effected in the working can be more easily realised by an examination of the daily ampere output curves of the station. Some of these prepared from information kindly afforded to the author by the Corporation accompany this paper. Horizontally each diagram represents the 24 hours from midnight to midnight, while, vertically, the total amount of the supply in amperes throughout the same period is indicated by the varying height of the curve line above the horizontal datum. The full line of the curve sets forth the work done by the dynamos, while the broken line shows the part taken by the storage battery, both discharging during the time the generating plant is stopped, as also while being charged by the dynamos. It will be seen from these diagrams, that from shortly before midnight until, at least, six o'clock on the next morning, or perhaps until noon, or after, the generating plant was always stopped; the result being a very considerable saving in coal and wages to the staff, and one which could not have taken place had the alternating system been in use, as no cessation in the working of the generating plant is possible therewith.

In order to indicate the progressive working of the undertaking, there is appended to this paper a tabular statement compiled from the half-yearly electricity accounts, issued by the Bradford Corporation during the four years 1890 to 1893. From these tables, the more fully to illustrate the progress which has been made, the author has been able to prepare a diagram (No. 1), which shows graphically the half-yearly amounts of (*a*) the working expenses, of (*b*) the gross receipts, of (*c*) the units sold, and of (*d*) the working cost per unit. From this diagram it will be seen that during the last two years, at least, the working expenses have been on an average only 50 per cent. of the gross receipts, and the working cost per unit 2½d. The selling price has been 5d. per unit throughout

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this period, and this low rate has this year been reduced, though for power only, to 3½d. per unit.

It may be of interest here to remark that already a fair and an increasing source of the day revenue has arisen in the sale of current for hoists, and for other small engines. Indeed, by the time when the Corporation tramways come to be worked by electricity from the central station, as the question of the relative expenditure upon wages, coal, and water is of special interest. The money values which have been paid, three-monthly, during the four years 1890-93 upon each of these items have been arranged upon a diagram (No. 2). By comparing this with No. 1 diagram, it is instructive to note that the amounts expended upon these matters have not increased in the same rate as

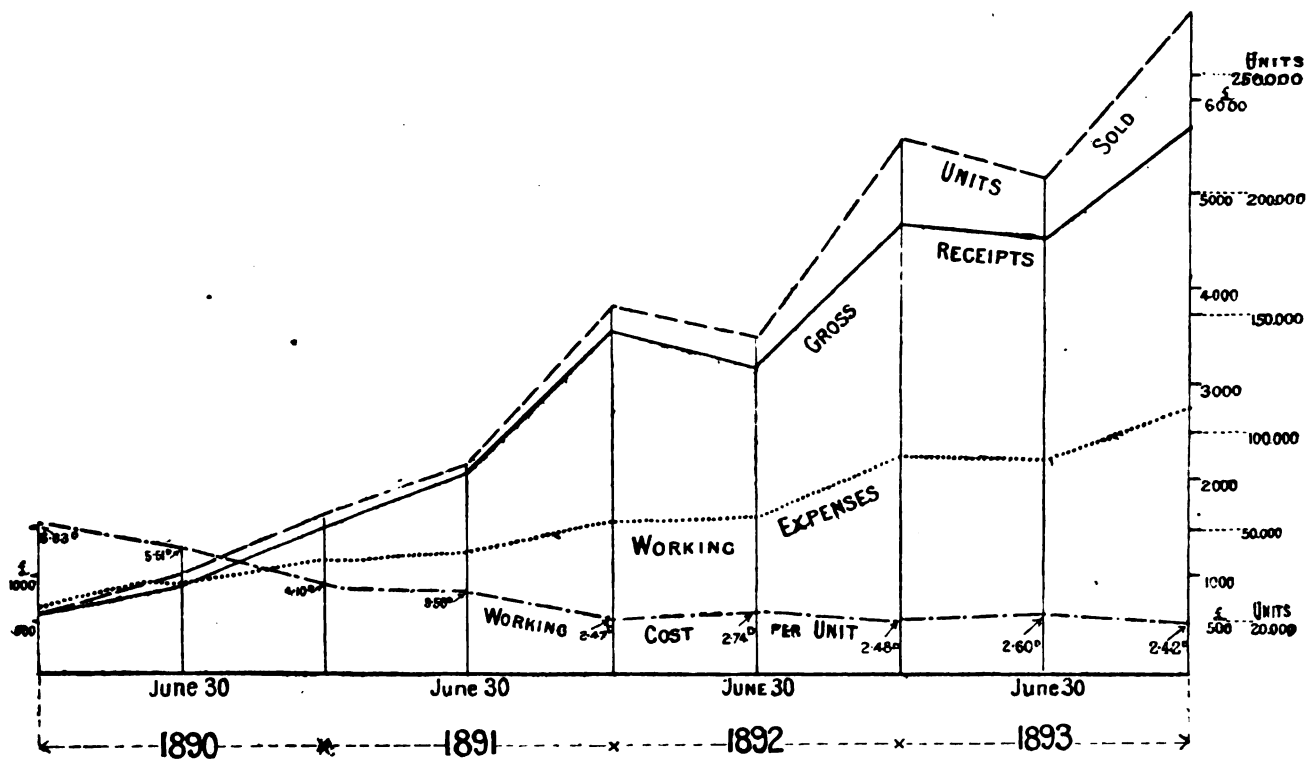

DIAGRAM No. 1.—Graphic Representation of Working Expenses, Gross Receipts, Units Sold, and Working Cost per Unit.

a series of experiments has shown to be feasible, the demand under the head of motive power will be considerable. Already the superiority of the "continuous" form of current for these applications (motive power, storage, etc.) is forcing itself upon the advocates of alternating currents, who now begin to perceive the value of some of the financial advantages to be derived therefrom, and which they has the output obtained. Or, in other words, that the services of the staff, as well as the steam-producing properties of the plant, have both been utilised to a greater extent than was the case in the earlier stages of the undertaking. The financial results of the four years' working of this electric undertaking, as shown by the half-yearly revenue, the interest and sinking fund, the profit

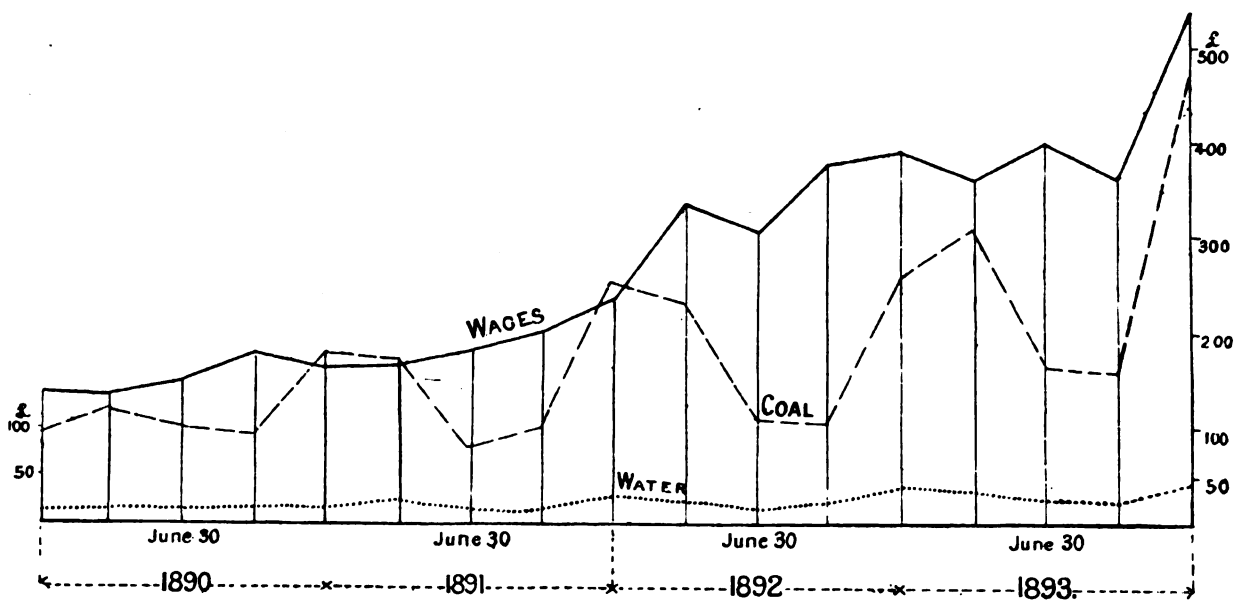

DIAGRAM No. 2.—Graphic Representation of Quarterly Expenditure upon Wages, Coal, and Water.

have hitherto thrown away; not to speak of the difficulties of distribution, in the conductors and in other ways, which the use of the "alternating" current brings with it. These objections they would now seek to get over by "redressing" the current, that is, by reconverting from an "alternating" back again into a "continuous" one. But why ever have departed from the original "continuous" form, with which they were bound to start? To engineers and loss and the capital expenditure accounts respectively, of the Bradford Corporation, may be put briefly in the following terms: not merely have the working expenses been met from the commencement, but also the interest on the municipal loan, together with the proportionate annual contribution towards the sinking fund for the repayment of that loan, have been paid, even during the construction of the works. Of course, during the early days the receipts

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did not suffice to meet these two last items, amounting in themselves to nearly 7 per cent. on the capital in use; so rapidly, however, has the demand for electrical energy grown in Bradford, that the whole of this "leeway" has been made up (as may be seen from the profit and loss account) and a balance of profit left at the end of 1892, or in three years after the commencement of the supply; while by the end of 1893 a sum of over £2,000 had been placed to the clear profit of the undertaking. In fact, for the last two years, at least, the balance of gross profit over ordinary working expenses has amounted to a return of about 10 per cent. upon the capital then expended—a result which is most exceptional in the history of municipal enterprises, considering the short period during which the present undertaking has been in operation.

It may probably be of further interest to the meeting if some comparison could be presented between the "rates per unit" which have been reached at the Bradford electric undertaking, and those which occur at some other similar ones which have been longest working in this country. For this purpose the returns to the Board of Trade for 1893 would offer the most reliable basis, while limiting the selection to those works which have been in operation for at least three years, since it would be manifestly unfair to the more recently established ones to compare their economical results while they are still in what may be termed their initial stage.

COMPARATIVE "RATES PER UNIT" IN 1893.

	Capital expended.	Working cost.	Sale price.
Continuous Low Pressure.	s. d.	d.	d.
Bradford	2 4	2·5	5
Kensington and Knightsbridge	4 10	4·2	7
Liverpool	4 9	2·9	7
St. James's and Pall Mall	3 8	3·7	6
Westminster	4 5	4·0	6
Alternating High Pressure.			
Eastbourne	6 0	5·2	9
House-to-House (West Kensington)	4 3	5·2	8
Metropolitan	4 2*	4·6*	6
Newcastle District (Parsons) †	2 4	2·6	4½
Newcastle-on-Tyne (Brush) †	2 6	2·9	4½

* This figure can only be approximate; no return having been made to the Board of Trade as to the number of units sold.

† These two undertakings ought, for the purpose of comparison, to be taken as one.

Ten well-known undertakings have been selected as fulfilling the above conditions; five of these are working on the "continuous" current system at "low pressure," and provided with storage batteries, and the remainder on that of the "alternating" current at "high pressure," and, of course, without storage. The result of the above comparison shows that the Bradford undertaking works as cheaply as the Newcastle ones, where coal is very cheap, and more economically than any of the other stations in England.

From the facts which have been detailed in this paper it is evident that the ratepayers of Bradford have no cause to regret, financially, the results of the action which their Corporation have taken in providing them with the advantages of a supply of electrical energy. It must likewise be a source of satisfaction to feel that this has been done without exposing the inhabitants to those serious risks to life which occur with the "high-pressure" current, and which have already led to fatal accidents in other towns. Results such as are described in the paper are remarkable, and redound very greatly to the credit of those Corporation officials at Bradford who have especial charge of the working and management of the undertaking—more especially of the late chairman (only recently resigned) Alderman F. Priestman, J.P.; of the worthy and respected town clerk, Mr. W. T. McGowen; and more particularly of the resident managing engineer, Mr. S. W. Baynes. The author can fully appreciate the thorough business qualities of the alderman, and the kindly assistance which he himself has ever received at his hands (while acting as electrical engineer to the Corporation) in the design and during the construction of the present works, as well as in the earlier years which preceded their construction; while as regards Mr. Baynes, he has had even a longer acquaintance of him, extending—electrically at least—into almost prehistoric times: he can therefore fully appreciate the care, diligence, and attention to the smallest details which have always characterised Mr. Baynes's management, and which have so largely conduced to the working results described in the paper. No attempt, however, to chronicle the history of electricity in Bradford would be complete without reference to the ever courteous and energetic town clerk, as most probably, or rather most certainly, had it not been for his unceasing exertions in favour of electric lighting during the past dozen years, the results which have been described in the paper would not have had any existence, at least, for some years to come.

In conclusion, the author must also thank the Corporation for their having so kindly placed at his disposal, and so unreservedly, the large amount of information which has enabled him to place before the meeting the principal facts contained in this description of the results of the four years' working of the Bradford Corporation electricity supply.

The second paper, by Mr. R. Hammond, on "Electric Street Tramways," was taken as read. We shall give an abstract of this paper in our next issue, together with a report of the discussion on the two papers.

THE GAS AND ELECTRICITY SUPPLY OF BLACKPOOL.*

BY WILLIAM CHEW, M.I.E.E., BLACKPOOL.

(Concluded from page 730.)

I will now describe the new electric works as fully as possible that we may be acquainted with the class of competitor the new agent is likely to assume. Wherever electricity works are first commenced for a general supply, it is difficult to forecast precisely the amount of light immediately required; but in Blackpool there are exceptional circumstances that cause a very large demand in proportion to the size of the town, from the existence therein of so many places of public resort which vie with one another. An approximate estimate was based on the requirements of these places, and a 200-unit incandescent lamp plant, with an 82-unit arc lamp plant, was fixed upon. Acting on this, electrical contractors were invited to submit estimates and designs, with the result that the works have been erected at a cost of £30,000. It was thought a large outlay; but it was estimated that if only one-half was immediately put in operation, there would be little loss, whilst if the output should ever reach the capacity of the plant, then the profits would fast accrue, owing to certain fixed charges being almost stationary. This is the universal opinion of all electricians, even those that have half a million of capital laid out. The system adopted was that known as the alternate-current high-pressure system, with a converter to low pressure fixed in each consumer's premises; and for public lighting, a separate plant on the direct-current high-pressure series system.

The works, which adjoin the gasworks and their sidings, consist of a boiler-house 123ft. by 68ft., and a producer-house 123ft. by 55ft. There are three Lancashire boilers, 28ft. by 7ft., fitted with mechanical stokers, and apparatus intended for the consumption of smoke.

The producing plant for incandescent lamps consists of

		Volt.	Amp.	Rev. per min.
No. 1*a*—100-unit rotary alternator	...	2,000	× 50	... 375
,, 1*b*— 50 ,, ,, ,,	...	2,000	× 25	
,, 1*c*— 50 ,, ,, ,,	...	2,000	× 25	
Total... 200-unit output capacity.				

The driving power for these consists of compound coupled horizontal non-condensing engines.

No. 1*a*—200 i.h.p. at	90	revs. and	125lb.	steam
,, 1*b*—100 ,,	120	,,	125	,,
,, 1*c*—100 ,,	120	,,	125	,,

the driving power for these being imparted by cotton ropes.

The Arc Light Plant.

No. 1 dynamo	27½	units, maintaining	55	arc lamps of	10 amperes.
,,	27½	,,	55	,,	,,
,,	27½	,,	55	,,	,,
Total ...	82½	units ,,	165	arcs.	

These machines run at the rate of 800 revolutions per minute, and are each driven by a 60-i.h.p. engine, the same type as the others.

This constitutes the plant of the producer-house, the current being taken from each machine to a distributing board for combining or by-passing the various circuits required. A testing resistance equal to the output of the largest producer is provided

* Abstract of paper read before the Incorporated Gas Institute.

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to be used when required. A suitable overhead crane for repairs is fixed to travel on the walls, and beyond several small testing instruments for measurement of current and pressure regulators, this constitutes the whole of the generating plant. In the distribution of the current great care has to be exercised in apportioning the sizes of the mains, owing to the cost of copper contained in them, and the loss of pressure if at all too small; for with too small leads it is easy to expend 50 per cent. of the production in overcoming the resistance. The distributing mains are laid in 3in. and 4in. diameter T and B pipes on each side of the streets, in straight lines, with a brick eye at easy distances. The cables are stranded copper wire, insulated with vulcanised indiarubber, and threaded into the pipes. These were laid without attempting to keep them watertight, as the quality of the insulating material was so good. Being laid in straight lines, about 18in. deep, they necessarily overlap the gas-mains; and are liable to accumulate gas therein owing to disturbance of the earth in laying them. The effect of this will probably be seen later on, when the precise nature of the disturbance has been forgotten. The main leads are taken along some of the principal streets, at 2,000 volts pressure, and to consumers' houses, where the converters are fixed to yield 100 volts pressure to feed their lamps. A two-night test at one consumer's premises shows the effective pressure obtained therein.

Time.	Pressure, volts.	Time.	Pressure, volts.
7.10	108	7.25	111
7.22	104	7.40	107
7.25	94	7.41	94
7.28	96	7.47	99
7.30	94	7.50	96½
7.40	93½	7.58	97½
7.45	94	8.0	100
7.51	96	8.1	96½
8.0	94½	8.13	96
		8.30	96½

From this it will be perceived how difficult it must be to keep at 100 volts steadily if under penalties. There have been about 8,000 yards of mains laid containing 20 lineal miles of wire; and on these are fixed about 60 consumers, several being very large ones. The public lighting is carried out on a brilliant scale on the Marine Parade, the lamps being about 50 yards apart and 25ft. high. They each use half a unit of current per hour, and are known as 2,000 nominal candle-power. In the main streets 25 others are being erected. These displace 200 gas lights. The works were put in operation on August 1, 1893, and the cost was as follows:

Land (rented)		
Buildings	£8,008 = 26½	per cent.
Apparatus	10,500 = 25	,,
Mains and services	7,000 = 23½	,,
Lamps and posts	4,000 = 13½	,,
Meters, etc.	500 = 1½	,,
Total	£30,008 = 100	,,

The output of the plant is calculated at 150,000 units per annum, or = 4s. per unit made. In order to push the new light, the usual pamphlet was issued setting forth the hygienic capacity of the light in comparison with gas, and a few rules as to insulation requirements of consumers' leads. Canvassing consumers is strongly pursued also. The scale of charges for current are scheduled as follows: incandescent lamps by meter at 6d. per unit, with a discount ranging from 5 to 25 per cent.; for private arc lighting, 2d. per hour for half-unit lamp equals 4d. per unit, less 10 per cent. discount; promenade and town lighting at actual cost of current, plus maintenance. As a result of starting the plant, the guaranteed customers to the extent of about 60 were quickly supplied, one of these taking alone fully one-third of the entire private consumption. The Corporation themselves are also large users, coming in for nearly half the total output, which for the eight months previous to March 25 was:

Produced at works for private use	55,600 units.
,, ,, public lamps (only half lit during winter)	22,560 ,,
Total	78,160 ,,

The works are now employed at their maximum output, the reserve plant being encroached upon thus:

Available output in one hour = 200 units	
Actually in use	195 ,,
Balance (reserve)	5 units, or 2½ per cent.
Arc Plant.	
Available	155 arcs
Actually used	140 ,,
Reserve	15 arcs, or 10 per cent.

The following weekly output from the works will give an idea of the extent of the lighting since the commencement (September 1, 1893, to March 1, 1894).

SCHEDULE OF OUTPUT PER WEEK FROM SEPTEMBER 1, 1893.

Date.	Alternating.	Public.	Private.	Total.	Working cost. £ s. d.
1893.					
Sept. 9	1,265	—	—	1,265	47 5 5
16	1,691	—	—	1,691	44 6 0
23	2,086	—	173	2,259	42 17 1
30	2,026	—	337	2,363	48 11 3
Oct. 7	1,620	—	128	1,748	51 9 1
14	1,800	—	195	2,435	63 3 3
21	1,693	1,332	102	3,107	72 9 4
28	1,594	1,349	128	3,071	68 10 4
Nov. 4	1,685	1,369	140	3,194	64 19 1
11	1,786	992	195	2,973	59 19 4
18	1,660	895	98	2,653	41 6 9
25	1,628	823	133	2,584	39 10 4
Dec. 2	1,727	842	157	2,726	39 18 10
9	1,838	861	281	2,980	41 5 8
16	1,779	888	202	2,869	39 12 3
23	1,797	929	104	2,830	38 1 1
30	1,880	993	246	3,119	41 11 3
Units	29,555	11,713	2,619	43,867	845 16 4 = 4·7d. per unit
1894.					
Jan. 7	1,781	948	145	—	—
14	2,150	959	355	—	—
21	1,903	943	238	—	—
28	1,726	877	236	—	—
Feb. 4	1,922	793	278	—	—
11	1,728	816	220	—	—
18	1,566	896	92	—	—
25	1,634	745	114	—	—
26 & 28	691	311	43	—	—
Estimated to March 25	44,656	18,911	3,940	—	—

Summary.	Units.
Produced to March—Incandescent lamps	44,656
,, ,, Public lighting	18,911
,, ,, Private arcs	3,940
	67,507
March 25, est.	10,719
Total product	78,226

As there are several more customers ready to come on, the extensions of the mains to supply them have already been put in hand, and a temporary plant has been put down till the permanent one can be erected. This new outlay will raise the capital to about £50,000, and the incandescent capacity will then be raised from 200 units to 450 units per hour.

One result peculiar to new electrical works is that the cheap high-tension distributing pioneer system of separate transformers has in six months to be replaced with a new low-tension system of distribution in the centre of supply by means of half-a-dozen transformers placed in the streets. In this way the difficulties attending the pioneer work will be reduced, as all house transformers will be abandoned where this system prevails. This is the second step towards having a central transformer station in the middle of the town where the future current will no doubt be distributed from, forming what is known to gas engineers as a town governor-house.

The result of the first half-year's working can hardly be taken as a standard of future costs, the plant being partly in the hands of the electrical contractors, so that many items chargeable will consequently not appear. Besides this increased output for longer periods is expected from the plant hereafter, which should tend to reduce the comparative costs. The total output to March 25 has been:

August 1 to December	43,867	units
December to March 25	34,359	,,
Total	78,226	,,
		Per unit.
The working cost of producing this has been	£1,774	= 5·44d.
Proportion of interest only chargeable for this period	629	= 1·93
	£2,403	= 7·37d.
Add if the whole interest and sinking fund for eight months had been chargeable = £1,150 at 5½ per cent.	521	= 1·60
Total	£2,924	= 8·97d.

The cost per unit sold is rather difficult to apportion in this necessarily experimental period, owing to waste caused by trials of plant, and which are recorded in the output only, and might be misleading. The loss on distributing of the incandescent system alone is about 25 per cent. of the output; that for the arcs being almost negligible, owing to the mains being in use during the time of actual lighting only. This working cost is undoubtedly a high figure in comparison with the selling price; but as the plant has reached its maximum capacity, and the

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working cost has had the advantage of freedom from repairs, rates, and depreciation, it is clear that any reduction on cost must be in the direction of longer average daily loads, coupled with sundry economies, and the very doubtful advantage of a larger station. I have not given a detailed cost of the eight months' working, and think it more reliable to give later details now we are in fair working order, as being more accurate.

TABLE showing the Working Cost for several Weeks during April and May, which is the Period of Small Demand for Lighting, excepting Whit-week, when, being Holiday Time, a Large Increase of Output is requisite here.

—			—			Reserve full hourly capacity.		
No. 1 week.		Units.	No. 2 week.		Units.	No. 3 week.		Units.
Output.....		2,793	Output		2,424	Output		4,063
	Per cent.	Units.		Per cent.	Units.		Per cent.	Units.
Estimated loss in mains...	16·4	=460		18·9	= 460		13·5	= 550
Estimated loss in transformers	19·3	=540		22·2	= 540		15·7	= 639
Used at works...	3·7	=106		4·4	= 108		2·6	= 109
Loss	39·4	=1,106	1,106	45·5	=1,108	1,108	31·8	=1,298 1,298
Accounted	60·6		1,687	54·5		1,316	68·2	2,765
Estimated revenue.			Units.			Units.		Units.
Metered incandescent			806	Incandescent		481	Incandescent	1,829
Arcs 54 }			881	Arcs 122·5 }		835	Arcs 277 } ..	936
,, 827 }				,, 713·0 }			,, 659 }	
Total			1,687			1,316		2,765
Coal used— T.C. 29·5=38·8lb. per unit sold.				T.C. 29·5 = 49·8lb. per unit sold.			T.C. 31·12 = 32·6lb. per unit sold.	
Working costs—		Per unit sold.			Per unit sold.			Per unit sold.
Coal	£13 9	9...1·8d	£14 15 3 ..		2·6d.	£14 16 9 ...		1·3d.
Oil and engine stores	3 8	6...0·4	4 5 3 ...		0·8	3 19 4 ..		0·3
Water ...	2 19	6...0·4	2 17 0 ...		0·5	3 12 0 ...		0·3
Engineer.	5 0	0...0·7	5 0 0 ...		0·9	5 0 0 ...		0·4
Electrician	6 0	0...0·8	5 13 6 ...		1·0	5 12 6 ...		0·4
Wages ...	10 5	7...1·4	10 2 7 ...		1·8	11 3 3 ..		0·9
Repairs and maintenance...	—	—	—			—		
Works cost	£41 3	4...5·8	£42 13 7 ...		7·7	£44 3 10 ...		3·8
Rates and taxes ...	1 12	0...0·2	1 12 0 ...		0·2	1 12 0 ...		0·1
Insurance	0 2	6 —	0 2 6 ...		0·01	0 2 6 ...		—
Office, lab., and gen. expenses	4 12	0...0·6	4 12 0 ...		0·8	4 12 0 ...		0·4
Int. and sinking fund.....	31 0	0...4·4	31 0 0 ...		5·6	31 0 0 ...		2·6
Total costs	£78 9	10...11·1	£80 0 0 ...		14·5	£81 10 4 ...		7·0

From these working costs it is clear, in comparing week No. 3 with Nos. 1 and 2, that increased output for the heavy week caused decreased cost, and the net result for the year depends on the total output the plant is required to supply. It would require an average weekly output of 4,000 units, or 208,000 units per annum, to enable the works to sell electricity at 7d. per unit, which is the cost for week No. 3, when the whole plant was employed in producing 4,000 units. The amount earned at the prices charged, I think, need not concern you, as the cost price is the datum which ultimately fixes the commercial value in comparison with that of gas. Having placed before you the result of the working, it remains to be seen what has been the effect on the gas consumption during the period when 78,200 units of electricity were made, or a sale of about 58,000 units, being the equivalent of 5,800,000 cubic feet of gas. Well, during this period there were sold 180,000,000 cubic feet of gas, as against 150,000,000 the previous year, or an increase of about 30,000,000; our increase being five times the sale of electricity sold during the same period. To say that the effect was nil, is true in one respect only; for the output of gas has increased—owing partly to the addition of 300 new consumers, and partly to the more general use of gas. Had there been no electricity works, I think we should have had about another million cubic feet of gas sold. Taking 30 of the largest consumers of electricity, and comparing their accounts with the corresponding March quarter of 1893, we arrive at the relative effect on old consumers they take up :

	Cubic feet of gas.	Electricity.
30 consrs. used March qr., 1893	2,936,000 at 2s. 6d. = £366	— £366
30 ,, ,, ,, 1894	2,360,000 at 2s. 6d. = 295	£396 691
Less used.....	576,000 ... Less £72	

So that for the £72 worth less gas used, they took £396 worth of electricity, making the total lighting account £691, against £366—being an increase of £325 for the quarter in their accounts.

To summarise, it is evident that wherever electricity is used, less gas is burnt, and of the new customers hereafter it will take a share thereof. Electricity undoubtedly being a good light for business purposes, where its principal consumption lies, increased demand will continue until what is termed the "saturation" of the district is reached. The precise amount of this one can hardly foresee, and I think there is undoubtedly room for both systems in most towns—the extent varying with the peculiarities of each. Hereafter, with a dual supply in operation, the gas industry will have to be satisfied with less than the whole loaf, so to speak—a slice being taken off by electricity; so that the general effect will be that a gas company will be relieved to some extent of that great increase which has taken place in gas consumption yearly.

ACCUMULATOR CARS IN SYDNEY.

Some time ago the New South Wales Railway Commissioners, noting the improvements which have been effected in the accumulator system as applied to street traction, and also having in view the question of improving the tramway system, gave instructions for an experimental car to be constructed at the Randwick workshops. The car has been completed, and various trials have been given in order to demonstrate its suitability for use on the lines in Sydney.

The car is of the same pattern as the standard cars in general use, with the exception of the ends, which are rounded to allow room for the driver. The *New South Wales Railway Budget* states that the energy is contained in seven boxes of accumulators of the Planté type, as recently modified by Mr. Epstein. These are encased in the body of the car, and are capable of supplying 20 h.p for five hours' actual running, or a larger power for a proportionately less time. The motors, one on each bogie, are nominally of 25 h.p. each. They are of the latest type used on the large electric tramways in the United States, and are practically noiseless, the gear being protected by closed boxes containing oil. Electric lamps are fitted in the smoking and non-smoking compartments, and electric head-lights are used. A power brake has been specially designed for use with this car, worked by electricity, which distributes the brake pressure over all the eight wheels equally, and can be graduated with the greatest nicety. The driver stands with the general controlling and reversing handles on his left hand, and at his right the electric brake. A hand brake is also provided. The car is reversible, both ends being fitted in precisely the same manner. An ordinary car may be coupled on as a trailer.

The car was taken for a trial trip to Coogee on May 2, and in every way gave general satisfaction. The three commissioners entered the car at Bridge-street, and among the other passengers were Mr. G. Downe, locomotive superintendent; Mr. P. B. Elwell, electrical engineer; Mr. G. R. Cowdery, maintenance engineer; and Mr. J. Roberts, manager. This was not a test of speed in any way, the earlier portion of the journey being impeded by the presence of regular trams ahead, and the speed being altered at times to fully test the motors. It is believed that the car could do the journey in from 15 to 20 minutes, as it is stated that a speed of between 25 and 30 miles was easily put on during part of the journey. The car was taken round the loop at Coogee, and then back up the steep grades to Randwick. The run home brought the time of the round trip up to just an hour and a quarter, including stoppages, and the car seemed to have established a claim to be considered a success.

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THE
ELECTRICAL ENGINEER.

Published every Friday.

rice Threepence; Post Free, Threepence Halfpenny.

Editorial and Publishing Offices:
39-140, SALISBURY COURT, FLEET STREET,
LONDON, E.C.

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THE VALUATION OF PATENTS.

Those who have unfortunately to attend courts of law, and to hear the various questions and answers and opinions on the value of a patent, must long since have wished that some guiding principle could be established in such valuations. If it be possible to do so, then some kind of agreement might be come to as to the value which can be justifiably placed upon a patent offered for sale, or purchased. We know of but one guiding line, and that, if followed, must allow of fairly wide divergences as to estimates. At the present time, however, the value of a patent is first what you can get for it, and the veriest rubbish may be appraised at hundreds of thousands of pounds if in the hands of good company promoters, while an intrinsically more valuable patent has to be sold for a mere song. It seems to us that the valuation of a patent ought to proceed upon some such line as is indicated by what follows. Take, in the first case, an improvement in some well-known piece of machinery. Admit the validity of the patent. In the ordinary course of business an income will be derived from that patent only by its being added to the whole or part of all new machines of the kind it is designed for, and also added to the whole or part of the machines already in use. Now, the life of the patent, so to speak, extends over a period of fourteen years—that being the time legally conferred upon the holder during which its manufacture is a monopoly. The holder has, in the first place, to make the nature of his improvement known, and, in the second place, to convince users of the machinery that it is an improvement. These things cost money. Further, as soon as the improvement becomes public knowledge, and is seen to be an improvement, there is a class of pickers and stealers which has for its object the improvement of improvements—the getting round of patents by modifications of detail, and too often some one or more of these modifiers succeed in achieving their object. The valuer, then, ought to be an expert who can to some extent gauge the possibility of getting round the original patent. Even if successful, the original patentee or his holder has to fight in the Courts for his rights, and then incur very heavy legal expenses. By some such exhaustive system of reasoning we ultimately come to the view that having a monopoly—having an article which possesses undoubted utility—it is possible during fourteen years to build up a considerable business in that article, and at the end of the fourteen years that business will have a marketable value called "goodwill," even when the possibilities of competition are considered. That marketable value of the business thus produced we deem the correct and proper value of the patent if valued at any time during its life. In our estimation the value of a patent in one sense depreciates every year of its existence, but, on the other hand, the goodwill for the business obtained by its means increases. This depreciation and increase should each year equally balance, so that from our point of view there is one constant amount standing in the

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books of a firm or company giving this value of the patent. The amount is, except during the first and last years of the patent's existence, made up of two amounts—one entitled "value of patent," the other, "derived goodwill from the working of the patent." During the first year the total is put to "value of patent," during the last year to "goodwill." The value of a patent certainly does not lapse with its death at the Patent Office, unless, indeed, it is something which is in demand for fourteen years only, and has no permanent value. It certainly does in many cases enable a business to be made or improved, and that business goes on even after the patent has lapsed. Of course, the valuer of a patent on these lines must be something more than someone in the City, and must consider much beyond the necessities for a prospectus or the floating of a company.

CORRESPONDENCE.

"One man's word is no man's word,
Justice needs that both be heard."

EFFICIENCY OF ELECTRIC MOTORS.

SIR,—You may be interested to hear that a result as far as we know unparallelled, has recently been achieved by Messrs. Mavor and Coulson in motor construction. They have recently supplied us with a 500-watt Sayers motor, for 500 revolutions per minute, which weighs under 2cwt., and has an electrical efficiency of over 90 per cent. This is such an enormous advance on ordinary practice that we think it only due to our *confrères* who may be interested in motor design to state that we shall be pleased to put the machine at their disposal at any time for inspection or test.—Yours, etc.,

THE BATTERY AND MOTOR COMPANY.

London, June 23.

ELECTRIC LIGHT IN A WEST-END HOUSE.

The problem of suitably adapting valuable chandeliers and other such contrivances to the service of electric incandescent lamps is not by any means an easy one to solve, though the electrical engineer is continually being called upon to undertake the task. Amongst those who have had this experience may be mentioned the gentleman who was called in by Mr. John Murray, the well-known publisher, to supervise the conversion of some fittings for his house. These, when finished, were seen and admired by Mr. Burdett-Coutts, who at once requested the same engineer to undertake an installation of electric light in the Piccadilly mansion of the "benevolent Baroness," as she is often called. The work of replacing candles and oil lamps with incandescent lights has just been finished; and to mark the event, a select few of Press representatives were invited by the Baroness and Mr. Burdett-Coutts to inspect, on Monday evening last, the completed arrangements. The total number of lights installed reaches about 580, though many of these are of quite small candle-power. In the magnificent cut-glass lustres or chandeliers—at least a century old—suspended from the ballroom ceiling there are nearly a hundred 2½-c.p. lamps, together with 20 or more 16 c.p. distributed amongst them. The lamp wires are led along the glass stems in the usual way, being secured thereto by fine binding wire, and are covered over with silver foil so as to be almost invisible in any light. Specially made glass pillars, bulbous at the top, and beautifully cut in horizontal or diamond shaped patterns (to prevent light from the incandescent filament actually striking the eye) are used for the nozzles at points where formerly the wax candles were inserted, and the remaining lamps are placed inside the rings of cut-glass drops. Much of the artistic arrangement and grouping of the lights must be credited to Mr. Burdett-Coutts himself, who has indeed kept in view throughout the two principles of retaining and adapting the old fittings and also of hiding from sight the bare white-hot filament of each lamp. In the picture gallery a specially fine effect is obtained by means of diffused light from above through frosted ornamental glass skylights in the ceiling, on very much the same principle as that adopted in the House of Commons. Since in the daytime these skylights are depended upon for sufficient light, it was a somewhat difficult task to so place the electric lamps that they should not obscure the glass in any way, but this task has apparently been quite satisfactorily carried out. The lighting of individual pictures, as, for instance, in the dining-room, is very successful in some cases, but not so much in others. It would seem almost as though the arrangement of lighting must be modified as to amount and direction for each picture, and no hard-and-fast system of top and bottom or side lighting can give complete satisfaction. Taken as a whole, however, the installation is extremely effective, and does great credit to all those concerned.

The installation has been carried out by Messrs. Townsend and McIntyre, Brook-street, W., under the supervision of Mr. V. G. Middleton, the consulting engineer, of 3, Princes-mansions, Westminster, S.W. The elaborate fittings previously used in the house for wax candles, oil, etc., have been altered and adapted to the new method of illumination by Messrs. Perry and Co., of Grafton-street, W., from whose factory have also come the new fittings required.

AN ELECTRO-CHEMICAL METHOD OF OBSERVING ALTERNATING CURRENTS.

In a recent issue of the *Comptes Rendus*, Mr. R. Janet deals with this subject. He states that there are two factors in connection with alternating currents which are not always easy to measure—viz., frequency and difference of phase.

The author has devised a graphical method offering great facilities for making measurements. Over a recording metallic cylinder is placed a sheet of paper which has been soaked in a solution of ferro-cyanide of potassium and nitrate of ammonia. An iron or steel style is made to press against this paper. The cylinder and the style are then connected respectively to the two points across which it is necessary to study the periodic E.M.F. As the circuit has no self-induction, the current will be in phase with the E.M.F. If under these conditions the cylinder be rotated, periodic blue lines will be produced corresponding to the maximum values of the E.M.F.'s. By this method frequency can be very readily measured. For measuring the difference of phase between two E.M.F.'s of the same frequency, it is only necessary to record the two impressions side by side, and to measure the distance between the two maximum values. By this method it would be easy to measure the difference of phase between the primary and secondary currents and E.M.F.'s of a transformer. The author has found this method capable of being applied to many cases.

Experiments were made on currents obtained from Zipernowsky alternators at 110 volts. (1) Three points—A, B, C,—on the circuit were taken, and separated by non-inductive resistances consisting of incandescent lamps. The point B was connected with the cylinder, and A and C with two styles. Under these conditions two discontinuous lines were obtained; the maxima of one separating into two equal parts the intervals formed by the maxima of the other. (2) An inductive resistance was inserted in place of one of the above non-inductive resistances. The difference of phase was immediately changed. The maxima of the discontinuous line corresponding to the inductive resistance separated into two parts, the intervals of the maxima corresponding to the lamp resistance.

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THE ANNUAL SHOW OF THE ROYAL AGRICULTURAL SOCIETY.

SOME OF THE EXHIBITS.

The fifty-fifth annual exhibition of this society was opened on Monday, at Cambridge, and will close this (Friday) evening. There is very little of interest to electrical engineers, but we give a summary of some of the principal engineering features of the show indirectly connected with electric lighting.

Great interest has been taken in the oil-engine competitions which were instituted by the society, and which concluded on Tuesday. The society offered in class 1 a first prize of £50, and a second of £25 for fixed oil-engines of from 4 b.h.p. to 8 b.h.p., and similar awards in class 2 for portable engines of from 9 b.h.p. to 16 b.h.p. The names of the competitors in the first class were: the Daimler Motor Syndicate, Limited, of 49, Leadenhall-street, E.C.; Weyman and Hitchcock, Limited, of Guildford; Samuelson and Co., Limited, of Banbury; the Campbell Gas-engine Company, Limited, of Halifax; the Britannia Company, of Colchester; Tolch and Co., of 146, Clerkenwell-road, E.C.; Fielding and Platt, of Gloucester; Holmes and Son, Limited, of Castle Hill, Norwich; Crossley Bros., Limited, of Openshaw, Manchester; Wells Bros., of Sandiacre, near Nottingham; Clarke, Chapman, and Co., Limited, of Gateshead-on-Tyne; and Richard Hornsby and Sons, Limited, of Grantham. In the second class the following firms competed: Weyman and Hitchcock, Limited; the Campbell Gas-engine Company, Limited; Clarke's Crank and Forge Company, Limited, of Lincoln; Fielding and Platt; Crossley Bros.; Clarke, Chapman, and Co., Limited; and Richard Hornsby and Sons, Limited.

At the close of the trials, Messrs. Hornsby and Sons were awarded the first prize of £50 for their fixed Hornsby-Akroyd oil engine of 8 b.h.p., and the first prize of £50 for their portable oil-engine of 12½ b.h.p. The second prize of £25 was awarded to Messrs. Crossley Bros., Limited, for their petroleum oil-engine of 6½ b.h.p., but the second award for the portable oil-engine has not been made.

Mr. E. S. Hindley, of Bourton, Dorset, exhibits a variety of his well-known types of vertical and horizontal engines, pumps, and band sawing machines.

The Britannia Company, of Colchester, and of 100 and 101, Houndsditch, London, exhibit the Britannia oil-engine, which works on the Otto cycle, and is made in sizes of from ½ h.p. upwards. The principal feature is the initial heating of the oil before mixing it with the air by means of the waste heat from the tube lamp, together with the vaporisation of the oil, and the further addition of air heated by the waste heat in the exhaust. The governing is effected by partially reducing the charge of oil to at least 50 per cent. of full power before cutting out a charge, thus making a steady-running engine. The engine is fitted with an automatic aid to starting, by which the pressure of compression is first removed altogether to give the charging stroke, then half compression to aid starting, and finally the working compression; this adjusts itself automatically without the man leaving the flywheel. Among other exhibits at this stand is an assortment of engineers' lathes, milling machines, shapers, etc.

Messrs. R. Hornsby and Sons, Limited, of Grantham, make a prominent display of oil and steam engines and agricultural implements generally. With regard to the oil-engines, the company show one of 8 b.h.p. This engine is capable of working with light or heavy oil of from ·800 to ·886 specific gravity, including ordinary petroleum lamp oil. The engine works with great economy without skilled attendance, and is suitable for estate works, electric lighting, and other purposes. A portable oil-engine, is also shown. It is of 12½ b.h.p. Various other oil-engines are likewise on view, and a portable steam-engine of 8 h.p.

Messrs. John Fowler and Co., of Leeds, exhibit, among other of their manufactures, one of their "Class A A" compound ploughing engines, of 12 nominal horse-power, fitted with their latest improved self-acting coiling gear and 450 yards of Fowler's "special quality" steel wire ploughing rope. More or less powerful engines are manufactured by the firm of a similar type—viz., of 20 h.p. (nominal) and 16 h.p. (nominal), also 7 h.p. and 8 h.p. (nominal).

Messrs. W. H. Willcox and Co., of 34 and 36, Southwark-street, London, S.E., show a collection of goods suitable for engineers, manufacturers, and users of steam and other motive power generally. The exhibits comprise their special engine and pump packings for pistons, valves, etc.; asbestos, indiarubber sheet; suction and delivery hoses for water barrels, pumps, etc.; new patent indiarubber hose and wire-bound hose; leather, cotton, and hair beltings; cylinder, lard, neatsfoot, and a variety of engine oils; boiler and engine fittings, and the Penberthy patent injector, besides gauges, cocks, valves, and lubricators.

Messrs. Tangyes, Limited, of Birmingham, are represented by a selection of gas-engines, steam-engines, pumps, etc. One of the gas-engines shown is connected to a pump and another drives a Siemens dynamo, supplying current to a number of lamps. The large engine exhibited by this firm is capable of developing 115 i.h.p. with ordinary town gas. Of the three types of steam-engines shown one is a horizontal engine fitted with Tangye-Johnson patent automatic cut-off gear, and has a 12in. cylinder and 24in. stroke. There is also a double-cylinder vertical steam-engine for confined spaces. Three sizes of the special steam-pump are exhibited, and the duplex type of pump is also shown.

Messrs. Drake and Gorham, of 66, Victoria-street, Westminster, make an attractive display of electric lighting at the stand of Messrs. Priestman Bros., Limited, of Hull, where the manner in which existing candelabra, old Moorish fittings, silver candlesticks, etc., can be utilised for use with the electric lighting is amply demonstrated. The firm have made a special study of installing the electric light with a view to giving the maximum of convenience and other advantages attaching to the system, and yet maintaining the same general effect as was formerly obtained with the wax candles and other soft and subdued lights. This system was the subject of much comment in connection with the successful electric light installation at Chatsworth for his Grace the Duke of Devonshire, and similar treatment has been carried out at Wynyard for the Marquis of Londonderry, Alnwick Castle for the Duke of Northumberland, and many other country seats. Were it not that the rooms are better lit than could be attained by the older systems, it would really be impossible for anyone entering the rooms to determine whether the light was electric or not, so effectually has all glare been removed by these special methods of shading, which have been from time to time developed by the firm. A special feature is made of a species of "Lotus" shade, which is made from paper in the form indicated, each petal being provided with a wire to maintain its position. These are made in delicately tinted shades which entirely obviate the unbecoming effect which has so often been attributed to the electric light. The imitation candles which are fixed in existing old candelabra have also been made a special study, with the result that it is impossible to separate the imitation candles from the best yellow wax. The firm also exhibit a D.P. accumulator, for which they hold the sole concession for the United Kingdom. This cell has been largely used for the past four years for supplying the current necessary after the engine has stopped. The chief feature in this cell is the low cost of up-keep which has been such a drawback in the past to the use of accumulators in country-house lighting. The dynamo from which the lamps on this stand are energised is of the E.C.C. type, giving 90 amperes at 135 volts, and it will shortly be laid down at The Rookery, Nantwich, for Baron von Schroeder.

Messrs. Priestman Bros., Limited, of Hull and London, exhibit their well-known oil-engines. These include a 20-h.p. double-cylinder horizontal engine, a 7-h.p. single-cylinder horizontal engine, a 2-h.p. single-cylinder horizontal engine and trolley specially designed for light agricultural purposes, and a 5-h.p. double-cylinder vertical marine oil-engine, with McGlasson's patent reversible propeller and shaft. Since the last Royal Agricultural Show various minor details have been improved upon which

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experience has suggested. The company state that, notwithstanding the depressed state of trade, they are now busy running day and night with orders for engines ranging in sizes up to 70 h.p. The steadiness and regularity with which the Priestman oil-engine runs has led to a large sale for electric lighting purposes alone, and the firm have lately received instructions to supply engines for this purpose to the Royal Engineers, Mr. T. H. Ismay, Mr. C. B. Wilson, M.P., Prof. Herkomer, R.A., Dr. W. Paget Tomlinson, Rev. J. D. Parker, LL.D., and others. One of these engines is shown in operation, driving an E.C.C. dynamo giving 90 amperes at 135 volts, and energising a number of lamps installed by Messrs. Drake and Gorham, and to which reference is made in another column. A number of repeat orders have been received, and these alone prove the value of the engine. The marine type of engine has also met with success, and is now being made in sizes up to 70 h.p.

Messrs. J. and H. McLaren, of the Midland Engine Works, Leeds, exhibit a selection of traction engines, engines for agricultural purposes, and hand-force feed pumps, etc. The hand-force pump, which was introduced at the Chester show, has had a good reception at the hands of the owners of portable and traction engines. The pump can easily be worked by a boy, and as it is double acting and fitted with an air-vessel, it supplies a continuous jet of water which will swill out the water spaces in the boiler. It can be used for a variety of other purposes.

Messrs. Crossley Bros., Limited, of Openshaw, exhibit a variety of their well-known gas and oil engines. The first to attract attention is an "Otto" horizontal improved type of gas-engine of 25 h.p. nominal, capable of indicating about 65 h.p. at a speed of 160 revolutions per minute. It is fitted with two flywheels 7ft. 1in. in diameter by 10½in. wide, and a pulley 60in. diameter by 23in. wide. The engine is of the latest type, with patent permanent tube, the company's timing valve, safety starting gear for preventing running back at starting, quiet air suction, sensitive high-speed governor, and patent starter. There are two horizontal gas-engines of 9 h.p. nominal and 3 h.p. nominal respectively. Another engine at this stand is an "Otto" horizontal high-speed gas-engine for electric lighting. It gives 2½ h.p. on the brake, and runs at 300 revolutions per minute. This engine is fitted with two flywheels, each 3ft. 6in. diameter by 2⅞in. wide, and is specially adapted for driving dynamos. One of the gas-engines is shown actuating an Elwell-Parker dynamo, which supplies current to a number of lamps installed by Messrs. Baily, Grundy, and Barrett, of Cambridge. Among the company's improved type of petroleum oil-engines may be cited one of 2 h.p. nominal, 4½ h.p. indicated, and 3½ h.p. actual. The speed is 200 revolutions per minute; the flywheel is 4ft. 6in. diameter by 4½in. wide. The consumption of oil is stated to be one pint per brake horse-power per hour at full load. A second oil-engine of 10 h.p. nominal and 17½ h.p. indicated, and a third oil-engine of 4 h.p. nominal and 8¼ h.p. indicated, are also on view. An oil-engine of 6 h.p. nominal and 13 h.p. indicated consumes three-quarters of a pint of oil per brake horse-power per hour at full load. A portable engine entered for competition is also to be found at this stand. It is made suitable for a continuous working load of 11 h.p. effective. It is mainly of the same construction as the stationary oil-engine made by Messrs. Crossley Bros., and works on the "Otto" cycle. The total weight of the engine in travelling order is 3¼ tons. The engine is carried on three wheels—a pair of large wheels, on which the bulk of the weight rests, and a small swivelling leading wheel, to which the horse-shafts are attached.

Messrs. Samuelson and Co., of Banbury, show Griffin oil-engines, for which they are sole licensed manufacturers in England. It is claimed for these engines that the starting is easy and prompt, the igniting point certain, and the ignition absolutely reliable. The consumption of oil, which may be common petroleum, is small, and in exact proportion to the work done after the necessary amount of oil has been allowed for overcoming the friction of the engine when running empty. The governors give perfect control, and the highest possible mechanical efficiency is obtained.

The Blackman Ventilating Company, Limited, London, display several of their well-known fans, one of which is driven by a "Trusty" oil-engine, and is fixed to a tubular air-warmer, such as are supplied to warm the large quantity of air moved by the Blackman fans, especially for drying purposes.

Messrs. Marshall, Sons, and Co., Limited, of Britannia Ironworks, Gainsborough, and Marshall's-buildings, 79, Farringdon-road, London, have on view a large assortment of their leading specialities. One of the most prominent is a 16-h.p. portable engine of the firm's patent type of flush-top boiler, with sliding carriages for the crankshaft, and the engine work carried on wrought-iron stays entirely independent of the boiler. This is a powerful engine, of ample strength for working at 90lb. steam pressure, and capable of giving off a large amount of power. The 7-h.p. portable engine shown is of the company's usual type, which is now so well known as scarcely to need description. It is provided with enlarged firebox for burning inferior fuel, and is made with wrought-iron crankshaft carriages, diagonal force pump, and all their latest improvements. Messrs. Marshall, Sons, and Co. have also various engines of their make driving the machinery on other makers' stands.

Messrs. Alfred Williams and Co. show, among other exhibits, the Halladay windmill, for driving deep-well pumps and dynamos. This type of windmill is claimed to be the only automatically self-regulating windmill. The wheel consists of a skeleton framework, into which a series of wooden sections are centred, which vary in number according to the size of the windmill. The sections are connected with counterbalance weights, which balance them to such a nicety that when the wind presses too heavily on them, as for instance, in a storm, the wheel opens and assumes a tubular form, allowing the wind to pass freely through it, which stops the windmill. As the pressure decreases the sails tilt back again into their old position, when the windmill recommences work. The vane at the back acts as a rudder and keeps the wheel always facing the wind. We understand that the windmill which was removed from Messrs. Carwardine's, on the City-road, has recently been re-erected at Okehampton, where it is driving a dynamo and a mortar mill.

Messrs. Ruston, Proctor, and Co., Limited, of Lincoln, exhibit an 8-h.p. new type portable engine. The crankshaft brackets, the cylinder, stop, and safety valves, and the bracket for carrying the guide and governor stands are bolted to planed seatings or supports riveted to the boiler, so that not a single bolt for holding any of these important parts passes into the steam space. These seatings are faced up by putting the boiler bodily into the planing machine, and as the parts which fit to them are also planed, an absolutely mechanical job is secured. It is thus evident that at any time the engine can be removed from the boiler and be mounted upon an independent bed-plate. In addition, immunity is obtained from leakage of steam joints. The cylinder is steam-jacketed, and the governor is sensitive, of the high-speed type, and acts on an equilibrium throttle-valve. The feed pump works continuously, and is perfect in action, water not required by the boiler being returned through a regulating cock to the feed tank. The boiler has a large firegrate with heating surface in proportion, is of sufficient size to develop three times the nominal power of the engine, and is well stayed for a working pressure of 90lb. The firebox is extra strongly stayed and fitted with fusible safety plug to prevent accident in case of shortness of water. The grate has been increased in length so as to be suitable for poor coal or wood.

Messrs. Robey and Co., Limited, Lincoln, show a horizontal steam-engine fitted with their patent automatic trip expansion gear. This engine is of substantial construction, suitable for doing heavy work, and is at the same time provided with a high-class expansion gear for securing the greatest economy in fuel and perfect governing under varying loads. It can be employed for driving a dynamo for electrical illumination. A compound Robey engine and locomotive boiler combined is fitted with patent automatic governor and link expansion gear, and is suitable for driving dynamos, mills, factories, and other machinery

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where steady running is required. In addition to the above, Messrs. Robey and Co., Limited, exhibit specimens of their medium and long stroke horizontal fixed engines fitted with their patent automatic governor and link expansion gear. The high-speed vertical engine exhibited is specially suitable for driving dynamos and other high-speed machinery, either by belt or by being coupled direct. The Robey horizontal fixed oil-engine (Richardson and Norris's patents) which is exhibited, is of the stationary type of eight effective horse-power. The cycle of operation is the now universal four-cycle, or Beau de Rochas—*i.e.*, an impulse is obtained every other revolution of the crankshaft when working up to maximum power. The engine proper closely resembles the Robey gas-engine, the only difference being in the combustion-chamber. There is also shown a Robey portable oil-engine of 10 effective horse-power. The design of the engine approximates closely to that of the portable steam-engine, and thus takes advantage of the years of experience which have proved that this is the easiest and most effective way of securing power in a portable form.

Messrs. Ransomes, Sims, and Jefferies, Limited, of the Orwell Works, Ipswich, have a large stand in the Machinery-in-Motion Department. The 6-h.p. and 8-h.p. portable engines on view have large steam-jacketed cylinders, wrought-iron crankshaft brackets, raised top fireboxes, and piston-valve governors. The 6-h.p. short-stroke engine is on a cast-iron foundation; the bed-plate, cross-head guides, and plummer blocks for crankshaft are all cast in one piece; the cylinder and valve chest are bolted to the end of the foundation frame. A four-horse vertical engine is connected with a new patent multitubular vertical boiler, which is so arranged as to present a maximum amount of heating surface in the smallest possible space, and ready access can be had to every part of the boiler for cleaning, etc.

Messrs. J. E. H. Andrew and Co., Limited, of Reddish, near Stockport, display two "Stockport" gas-engines. The first is an engine capable of developing 30 b.h.p. It is fitted with the company's self-starter, timing valve, ignition tubes, and an arrangement of governing by which the speed of the engine can be altered without stopping. This being very sensitive, it regulates the speed of the engine and controls the quantity of gas consumed in proportion to the amount of work done. The second engine develops 2 b.h.p. or actual horse-power, and is fitted with a sensitive vibrating governor and patent tubes. This engine is claimed to be one of the most economical engines of its size.

Messrs. Clarke, Chapman, and Co., Limited, of Gateshead-on-Tyne, display an improved type of fixed gas-engine of 35 b.h.p., constructed according to Butler's patents. This engine is specially suitable for driving dynamos for country mansions with Dowson's or other producer gas, the system of governing adopted rendering the running of the engine remarkably regular and uniform. Instead of using intermittently moving mechanism, such as cam-lift spring return poppet valves, levers, pumps, etc., the company have substituted one balanced, cylindrical, slowly rotating valve which performs the various functions. This valve is easily accessible, and can be removed for examination and replaced in a few minutes. The power and speed of the engine is capable of considerable variation. This is effected by a balanced regulator valve which admits an amount of explosive mixture to the cylinder, proportionate to the power and speed demanded, by means of which an impulse is obtained in every cycle and the engine given a very regular turning action. The engine is started by a small hand-pump by which the explosive mixture of gas or oil is supplied to a chamber, an electric exploder being used in connection with this and the cylinder. Two other engines, one portable and one fixed, are also on view.

Messrs. Clayton and Shuttleworth, of Lincoln, and 78, Lombard-street, E.C., are represented by a variety of their well-known manufactures. Among these is an 8-h.p. portable steam-engine. This engine is fitted with a jacketed cylinder and water-heater, and has an enlarged firebox of Low Moor iron or steel for burning wood or coal. The engine is constructed on a most approved principle for efficiency, economy of fuel, simplicity in its working parts, and durability. It is provided either with wood or wrought-iron travelling wheels. A second engine exhibited comprises a fixed long-stroke engine of 10 h.p. It is fitted with feed pump, patent governor, and automatic expansion gear; and is specially adapted for electric lighting purposes.

Messrs. Weyman and Hitchcock, Limited, of Guildford, display the "Trusty" oil-engine, which was also entered for the competition. The first to attract attention is the new pattern portable engine, capable of developing over 7 b.h.p., and fitted with patent water-cooling apparatus overhead. One of the principal points about this engine is that a few buckets of water are quite sufficient for a day's run. The oil-tank, which is placed very conveniently in the frame so as to feed oil-pump, is of a capacity capable of holding a supply of oil for two or three days' work. The engine is mounted on strong wrought-iron road wheels, with forged axles, and fitted with pole or shafts for draught. The whole arrangement is of compact design, and is specially handy for transport. A second oil-engine, horizontal, comprises one of 1½ b.h.p., or actual horse-power, and 2 i.h.p. This, like the portable engine mentioned, is a new departure, it being combined with a plunger pump, and capable of pumping 800 gallons of water per hour to a height of 100ft. Other exhibits at this stand are a single-cylinder horizontal oil-engine, working up to 6 b.h.p. and 9 i.h.p., and a single-cylinder horizontal engine, to work up to 7½ b.h.p., and suitable for using any of the ordinary oils. Some of these engines have been adopted for electric lighting, and one is shown driving a Statter dynamo supplying current to lamps on this stand, sawing, etc. A "Trusty" gas-engine has been installed on board the training ship "Conway," Rock Ferry, the engine being a double-cylinder one to give out 10 b.h.p., and running a dynamo feeding 120 lights.

Mr. C. Cadle, of 39, Wellington-quay, Dublin, exhibits a turbine manufactured by Messrs. Ridgway and Son, of Coatesville, U.S.A., capable of giving 5 h.p. He also has on view an improved impact waterwheel, adapted for driving mining machinery, dynamos, etc. Under a head of water 100ft., it will give 6 h.p., using 46 cubic feet per minute. The aermotor or windmill shown is made of steel, for pumping and other purposes.

Messrs. Pritchetts and Gold, of 31, Soho-square, W., demonstrate a complete electric lighting plant suitable for a country residence. It consists of a 9½-b.h.p. Hornsby-Akroyd oil-engine, a 200-light dynamo, set of 53 accumulators, switchboard with measuring instruments and regulator, and belting and connecting cables. This plant is capable of running 200 lamps of 8 c.p. or 100 of 16 c.p. continuously from the dynamo, or the full number from accumulators alone for 6½ hours, and half the number for 15 hours. Another exhibit comprises an electric pump of ½ h.p., manufactured by the C. & C. Motor Company, of New York, U.S.A. It is capable of raising 370 gallons per hour, can be worked off any incandescent electric lighting plant, and can be fixed at a considerable distance at small outlay. The Hunnings-Cone telephone, manufactured by the General Electric Company, of Manchester, is also shown on this stand.

MAGNETIC FRICTION AND HYSTERESIS.

Friction is a universal phenomenon of nature. Wherever motion, molar and molecular, takes place, energy is consumed by friction and dissipated as heat. Thus writes Mr. C. Proteus Steinmetz in the *Electrical World*. Continuing, he says: Thus, when iron is alternately magnetised and demagnetised, in the cycling motions of the molecules, which represent the change of magnetism, energy is consumed. This energy of magnetic molecular friction is converted into heat; the iron gets hot.

Since in almost all electro-dynamic machinery periodic changes of magnetism in the iron take place, it is obvious that the consumption of energy by this change of magnetism—*i.e.*, the molecular magnetic friction—is of the utmost importance as one of the fundamental factors determining the efficiency and the output of the apparatus. Thus, the predetermination of the molecular magnetic friction

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becomes necessary. If a piece of iron is magnetised and demagnetised alternately, it has been found that during the rise of M.M.F. the magnetism is lower than during the decrease of M.M.F., so that during the rise of M.M.F. the same value of magnetism is reached at a higher M.M.F. than during the decrease. This phenomenon is called hysteresis—*i.e*, magnetic lag. Thus, if a piece of iron is exposed to alternating M.M.F., the magnetism, as function of the M.M.F., describes a closed curve, the loop of hysteresis. The change of magnetism induces in the magnetising circuit E.M.F.'s, which consume energy, and it has been proven that the energy consumed by these E.M.F.'s is proportional to the area of the hysteretic loop. This loss of energy in the magnetising circuit during the alternation of magnetism is called the loss of energy by hysteresis. As seen, the loss of energy by hysteresis has directly no relation to the loss of energy by molecular magnetic friction. But the energy consumed by magnetic friction must be furnished somewhere, and if no external source of energy is applied, the hysteresis furnishes the energy of molecular friction. But even then the hysteretic loop need not be equal to the energy of the magnetic friction, but hysteresis may, besides molecular friction, furnish mechanical energy also. Some cases may illustrate this.

In the alternating-current transformer, energy is neither supplied to, nor expended by, the iron, except in the magnetising circuit. Thus, in this case, the hysteretic loop equals the energy of magnetic friction—*i.e.*, hysteretic energy and molecular magnetic friction are identical. If however, the iron pieces of the transformer are loose, so that they are set in vibration by the alternating field, the mechanical energy of vibration has to be furnished by hysteresis, and the hysteretic loop increases, representing now the sum of the energy consumed by molecular magnetic friction and by mechanical vibration. On the other hand, if the iron of the transformer is set in violent vibration by an external mechanical force, a part of the energy of magnetic friction is supplied by mechanical power and not by the M.M.F., and thus the hysteretic loop collapses more or less, representing now only that part of the magnetic friction supplied by the M.M.F. In this case the loop may even become negative—that is, energy may be put into the electric circuit by the magnetic circuit as an electric generator.

The conclusion from all this is that hysteresis can be used for measuring the energy consumed by molecular magnetic friction only, when care is taken to exclude any external source or expenditure of energy. But if external transformation of energy takes place, as in revolving machinery, no conclusion can be drawn from the hysteresis with regard to the magnetic friction, and especially disappearance of hysteresis does not mean disappearance of molecular magnetic friction, but means that the energy of magnetic friction is supplied from another source.

THE HISTORY OF WOODHOUSE AND RAWSON UNITED, LIMITED,

As Detailed in the Bankruptcy Court.

WEDNESDAY.

The public examination of the directors and officers of this Company, a report of which was given in our last issue, was resumed on Wednesday, before Mr. Registrar Hood, at Bankruptcy-buildings, Carey-street, Lincoln's-inn.

Mr. C. J. Stewart again attended as senior official receiver; Mr. Muir Mackenzie, Mr. Butcher, M.P., Mr. H. T. Eve, Mr. C. E. Jenkins, Mr. J. A. Cartmell, Mr. Mossop, Mr. H. G. Rawson, Mr. Kebbell, Mr. Pilling, and Mr. Stirling appeared for directors and others interested in the proceedings; and Mr. W. M'Kay (Ward, Perks, and Co.) for debenture-holders and also for the Official Receiver.

Before the examination was commenced, **Mr. H. G. Rawson**, on behalf of the directors, stated that the important documents, which on a former occasion were alleged to have been "spirited away," had been found in a place from which they had never been removed. He submitted that the insinuation ought not to have been made by the Official Receiver.

Mr. Registrar Hood said he was of opinion that the Official Receiver had conducted the examination throughout with the utmost fairness and impartiality.

Mr. F. W. Pixley, whose firm had audited the accounts of the Company, was again called, and, in reply to Mr. M'Kay, stated that he intended the special report annexed to his certificate of July, 1892, to be taken as part of the certificate, because he considered that the accounts were not altogether reliable.

By **Mr. Pilling**: He was not in any way concerned with the estimate of £75,000 as profit for the year 1889 as set out in the prospectus. He assumed that the balance-sheets were prepared under the direction of Mr. F. L. Rawson, and witness obtained much information from that gentleman with reference to the figures. The amounts were compared with the entries in the books. He was aware that in the original accounts the goodwill and patents of Woodhouse and Rawson, Limited, were represented by 100 founders' shares of £1 each, but there were also £20,000 in cash and £30,500 in fully-paid shares.

Mr. Pilling pointed out that the patent rights were returned in the accounts at £64,000 and the goodwill at £75,000.

The **Witness** stated that he had nothing to do with the preparation of those figures. He was not aware of the amount realised under the liquidation of the old company. With reference to the sum of £37,325 returned as a profit in respect of the International Okonite Company, Limited, witness said that the sum was included as profit upon the advice of counsel, which was taken at his suggestion. He certainly considered that the profits had been earned, but, as a matter of fact, the dividend was not necessarily paid out of them, as a dividend had been guaranteed in any case. There was no truth in the suggestion that he had withdrawn his report without having satisfied himself that his conditions had been complied with and the pledges fulfilled.

By the **Registrar**: He considered that when the goodwill was fixed by the directors upon the purchase it was impossible to run the figure up and down according to the fluctuations of the profit.

At the conclusion of his examination **Mr. Pixley** made a statement as to his connection with the Company. He said with reference to the original prospectus of Woodhouse and Rawson United, Limited, issued in July, 1889, it was not, he believed, even pretended that anyone incurred any legal or moral responsibility by simply allowing his name to be placed on a prospectus as auditor. He should, of course, satisfy himself as to the respectability of the directors and as to the purposes for which the company was promoted, but the publication of his name was merely an indication to intending subscribers that he would be the person who would eventually audit the accounts at the expiration of the first financial year. When an industrial business was converted into a public company it was usual to obtain a certificate of profits from a chartered accountant who would make a special investigation for that purpose. In this case he was asked to give such a certificate, and it was in evidence that he had declined to do this. Although reference was made to the profits shown by the audited accounts of Woodhouse and Rawson, Limited, none whatever was made to the fact of his being an auditor, and no intending applicant for shares had, he contended, any right to assume that such was the case. If anyone took the trouble to call for the accounts he would have ascertained that they were accompanied by a special report from the auditors. His clients, and his sole clients, were the shareholders of Woodhouse and Rawson, Limited. At the same time, however, he wished it to be distinctly understood that although he declined to accept any responsibility in regard to those who might subscribe to Woodhouse and Rawson United, Limited, he had no reason whatever to doubt that the amount of profit referred to on the prospectus was absolutely correct, and would be ultimately realised. He had never been consulted upon, nor had he seen any of, the subsequent prospectuses. With reference to the balance-sheets of 1890-91-92, witness submitted that he had done his duty in passing the accounts for those years. The balance-sheet of 1891, in respect of which he had proposed to present a report to the shareholders, but which was withdrawn, was not in the same condition after he had dealt with it that it was when laid before him. Many alterations were made in the accounts as the result of the threatened certificate. In that certificate he called attention to the fact that nothing had been written off patents or patent rights and charged against profit and loss. The accounts ultimately signed included a sum of £4,156 written off for depreciation of patents. An undertaking was also given that the amount due from Mr. F. L. Rawson should be paid off, and the debt was subsequently extinguished. Other pledges and assurances were also fulfilled. He wished to endeavour to clear up a misapprehension which seemed to exist as to what a company's balance-sheet really was. It was a mistake to call the credit side of the balance-sheet the assets side, as by the process of book-keeping, all expenditure, including the amount paid for goodwill, would go to the credit side of the balance-sheet. With reference to the balance-sheet of July, 1892, witness said he found the books in the greatest state of confusion, a very large number of vouchers for payments being missing. He also ascertained that the anticipations of the directors as to the sale of the shares were not being realised, and that money was being borrowed at high rates of interest. He, therefore, came to the conclusion that he could not to sign those accounts, and affixed a special certificate to them stating that it was necessary to make a special report to the shareholders, calling their attention to the general unsatisfactory position of the affairs of the Company. It had been suggested to him in the course of the examination that it would have been better had he issued such a report with the accounts of July 31, 1891. He admitted that in the light of present knowledge it might have been better if he had done so, but an auditor ought not to act upon impulse, and he considered that he was right in signing the accounts in 1890 and 1891. Witness added that the Board of the Company was composed of men of high reputation. They had been entrusted with the management of the affairs of the Company, and he had every reason to believe they were acting solely in the interests of the shareholders. Should an auditor suspect that the

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directors of a company were misapplying its funds or carrying on the business to their own interest at the expense of the shareholders, he might consider—and he was glad to say that the members of the Institute of Chartered Accountants did so consider—that an auditor should step outside what might be considered his bare duty and interfere, but in this case he had no such suspicion. He therefore submitted that he had done his full duty towards the shareholders of the Company, and that whatever blame might, as the result of this enquiry, be attributed to the officials, none whatever could be laid upon the auditors.

Sir John Stokes, K.C.B., was next examined by the Official Receiver. He stated that he had acted as a director of Woodhouse and Rawson, Limited, from the time of its formation, and subsequently was appointed liquidator of that Company, in which he was a large shareholder, and to that extent he was interested in the sale to the new company. He also became a director of the new company. So far as he was aware, the latter received all the patents and patent rights which were not reserved in the agreement. He did not consider that his positions at all clashed, and, as a matter of fact, he did not join the Board of the new company until after the allotment. He did not make any enquiries into the various agreements for the purchase of the buisnesses, nor into their position, but left the matter to the other directors, all of whom were competent men. When Sir John Coode, Colonel Howard Vincent, and Sir A. J. Cappel retired he took no steps to enquire into the position of affairs. He was not aware that the Woodhouse and Rawson Electric Manufacturing Company, according to the audited balance-sheet of June 30, 1889, began the year with a loss of £34,936 and ended the year with an accumulated loss of £44,718. The assets transferred to the United Company consisted partly of an option to call for certain Elmore shares, and of the profit returned in the balance-sheet of June, 1890, a sum of £29,437 was entered as profit in respect of those shares. Some doubt arose as to whether the shares had been transferred to the Company or not, but the liquidators of the old company gave way, and the United Company retained them. He could not say that one thing which induced the liquidators to give way was the fact that they were promised the return of the £75,000 deposited as a dividend guarantee fund. As a liquidator, he was naturally anxious that the fund should be returned, and he considered that he was acting in the interests of both companies in urging the return, as the larger part of the profits was being absorbed by the holders of founders' shares, and he wished to make it available for all the shareholders. He understood from the first that the Company was to carry on a financial as well as an industrial business. Reference was made in the first prospectus to the fact that a considerable profit had been realised from the first-mentioned branch by the old company. He admitted that the prospectus would give any reader to understand that the Company was carrying on an industrial business. He could not say that ever since 1887 there had been a continued loss on the industrial trading. Losses had been made on shares—in one case to the extent of £55,000. He could not admit that the "deal" in Elmore shares was the only successful operation carried out by the old company. With reference to the United Company, profits had been made over the promotion of the Kensington Co-operative Stores (£17,000) and the option to take Elmore shares, which realised a sum of £20,000. The profit of £35,000 in respect of the Epstein Accumulator Company, Limited, consisted merely of securities of that company. A sum of £46,000 had been invested in the Okonite Company, Limited, and witness admitted that this sum might have been used to advantage in the industrial business. In January, 1890, a prospectus was issued in which it was stated that, owing to the successful working of the United Company since its formation, an interim dividend at the rate of 15 per cent. on the ordinary shares and 8 per cent. on the preference shares had just been paid. He could not remember what accounts were before the Board when they declared that dividend, and after the lapse of five years he could not be expected to remember the reasons which induced him to consider that the profits had been earned. He denied that there was any special motive for making the third issue of shares coincide with the payment of the interim dividend. He was not aware until January, 1892, that Mr. Albert Grant was connected with the Phœnix Trust, of which Mr. F. L. Rawson was a director. He had nothing to do with the drawing of the prospectus, and did not see it until it had been issued, and he therefore could not accept any responsibility for the statements contained in it.

In reply to **Mr. F. L. Rawson**, witness said he attributed the failure of the Company largely to the depression in the financial business, owing to which the directors were unable to take up valuable patents. He had never known Mr. Rawson to act otherwise than straightforwardly.

Mr. M. J. R. Dundas, who acted as secretary of the Company, was also briefly examined by the Official Receiver. He stated that he was appointed upon the nomination of Mr. F. L. Rawson. He would not say that he was secretary in name only.

THURSDAY.

The examination by the Official Receiver of **Mr. Dundas** was resumed yesterday. The witness stated that he did not prepare a circular sent out relating to the retirement of three of the directors, but that it was sent out in the ordinary way of business.

Lord Aberdare, who was one of the original directors of Woodhouse and Rawson United, stated that he had a considerable interest in Woodhouse and Rawson, Limited. He understood when he consented to become a director that the idea of the new company was that it should be wholly industrial. He was present at the Board when the draft prospectus was finally settled, but just after he fell ill and was away from business for many weeks. In fact, he was away from the middle of July to the end of October and was not able to attend a meeting until December. He did not attend regularly until February. He found, however, that the duties were such as he could not well fulfil, and he ultimately resigned at the October meeting of shareholders. Referring to the report of the auditor for the year 1888, he remarked that it did not come before him at the time, but subsequently it became the subject of correspondence. Upon the question of stated profits, the directors examined everything very carefully and must have been satisfied before accepting the amount. They must also have investigated the amount for goodwill and for patents, and after careful examination they must have been satisfied. The fee stated as to be paid for valuation was, he thought, inadequate, but he was unaware of what the arrangement was. He had no special communication with retiring directors, nor of the minute nor circular; in fact, he did not agree with the terms of the minute. No doubt the question of interim dividend was communicated to him. He was astonished to learn about the auditor's report which was attached to Woodhouse and Rawson balance-sheet of 1888. A large amount of correspondence passed between him and other members of the Board relating to various questions upon which he required information. He stated that he always got the information he asked for as far as it was possible to be given.

Mr. A. Hoster was one of the liquidators of Woodhouse and Rawson, Limited, but a large part of his holding belonged to Mr. F. L. Rawson. He said that he did not recollect exactly why Mr. Rawson's shares stood in his name. He knew Mr. Rawson as a partner in Woodhouse and Rawson, and was consulted at the formation of the limited company, of which he became a director. He could not recollect Mr. Pixley's report to the 1888-9 accounts. He agreed that the amount due by the manufacturing company was £37,000, but could not state what was received for this debt. He had not realised anything from the shares of the manufacturing company. The supply company was also in debt to the amount of £11,000, and as liquidator he held 12,000 shares, but he recollected no specific amount received for these shares. He held £22,000 shares in the Universal Automatic Machines Company, for which he received 1s. each under the advice of the solicitors to finish the liquidation. They also owed a debt of £13,000, but it was valueless. He was a director appointed by Woodhouse and Rawson United, and on the Barcelona Company he acted as vice-chairman. He heard observations of a claim against Woodhouse and Rawson United. The debts of manufacturing company were collected and handed over to the United Company. He held that the debt of the manufacturing company at the time it was taken over was certainly good. He had expected to make a profit of from £60,000 to £70,000 on the Barcelona work. With regard to the Automatic Company there were arbitration proceedings which took between two and three years, and the arbitration was in favour of Woodhouse and Rawson United. The Automatic Company took up the award and went into liquidation; hence the claim for debt on account of shares was of no value.

ELECTRIC LIGHTING PROVISIONAL ORDERS.

The proposals contained in the provisional orders included in the Electric Lighting Provisional Orders (Nos. 3 and 5) Bills have been embodied in two official papers published on Wednesday. The following are extracts from the Bills:

Crystal Palace District Electric Lighting Order, 1894.—The undertakers under this order are the Crystal Palace District Electric Supply Company, Limited. The area of supply is portions of the district of the Beckenham Local Board, the borough of Croydon, the parish of Lambeth, the district of the Lewisham District Board of Works, and the parish of Camberwell. The order is to be read in conjunction with the Crystal Palace and District Electric Lighting Order, 1890, and varies the area of supply authorised by that order. The order also provides for the revocation of the Crystal Palace District Electric Lighting License, 1893.

Oswestry Electric Lighting Order, 1894.—The undertakers are the Oswestry Electric Light and Power Company, Limited. The area of supply is the borough of Oswestry. The order contains a provision that the undertakers shall lay down mains in certain specified streets within a period of two years, and it provides for the supply of electrical energy in the remainder of the area on certain specified conditions; and also a provision for the purchase of the undertaking by the local authority after the expiration of 35 years from the commencement of the order on certain terms specified in the order.

Plymouth (Corporation) Electric Lighting Order, 1894.—The undertakers are the Corporation of Plymouth. The area of supply is the borough of Plymouth. The order contains provisions that the Corporation shall lay down mains in certain specified streets within a period of two years, and it provides for the supply of electrical energy in the remainder of the area on certain specified conditions. The order also contains provisions for the approval by the Board of Trade of the system upon which energy is to be supplied, and the issue by them of regulations for securing the safety of the public and for ensuring a proper and sufficient supply of energy, and for the transfer to any company or person of the powers, duties, and liabilities of the Corporation under the order by means of a deed to be approved by the Board of Trade, upon such terms and subject to such exceptions and modifications (if any), and for such period, as may be specified therein.

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Shropshire Electric Light and Power Company Electric Lighting (Shrewsbury) Order, 1894.—The undertakers are the Shropshire Electric Light and Power Company, Limited. The area of supply is a portion of the borough of Shrewsbury. The order contains provisions similar to those referred to in the case of the Oswestry Electric Lighting Order, 1894. The order also contains provisions for the purchase of the undertaking by the local authority after the expiration of 21 years from the commencement of the order, or any subsequent period of seven years, on certain terms specified in the order.

Wakefield (Corporation) Electric Lighting Order, 1894.—The undertakers are the Corporation of Wakefield. The area of supply is the city of Wakefield. The order contains provisions similar to those referred to in the case of the Plymouth Corporation Electric Lighting Order, 1894.

Clonmel Corporation Electric Lighting Order, 1894.—The undertakers under this order are the Corporation of Clonmel. The area of supply is the borough of Clonmel, and portions of the district of the Board of Guardians of the Clonmel Union. The order contains provisions that the Corporation shall lay down mains in certain specified streets within a period of two years, and it provides for the supply of electrical energy in the remainder of the area on certain specified conditions. The order also contains provisions for the transfer to any company or person of the powers, duties, and liabilities of the Corporation under the order by means of a deed to be approved by the Board of Trade, upon such terms and subject to such exceptions and modifications (if any), and for such period as may be specified therein.

Collier-Marr Moss Side Electric Lighting Order, 1894.—The undertakers are the Collier-Marr Telephone and Electrical Manufacturing Company, Limited. The area of supply is the urban sanitary district of Moss Side. The order contain provisions: (1) that the undertakers shall lay down mains in certain specified streets within periods of six months and two years respectively; and it provides for the supply of electrical energy in the remainder of the area on certain specified conditions; and the order also provides for the transfer of the undertaking to the local authority by agreement, with the consent of the Board of Trade, and for the purchase of the undertaking by the local authority at any time before the expiration of 25, 35, or 42 years, on specified terms.

Yeadon Electric Lighting Order, 1894.—The undertakers are the Yeadon Local Board. The area of supply is the urban sanitary district of Yeadon. The order contains provisions similar to those referred to in the case of the Plymouth Corporation Electric Lighting Order, 1894.

COMPANIES' MEETINGS.

ELECTRIC AND GENERAL INVESTMENT COMPANY, LIMITED.

The fifth ordinary general meeting of this Company was held on Tuesday at Winchester House, Mr. George Herring presiding.

The **Chairman** said the profit and loss account showed a gross profit on the transactions of the year of £10,735, and after deducting all standing charges and the interim dividend already paid, there remained £7,369 available for distribution. The directors had made a provision of £8,000 for contingencies. The contingent liability amounted to about £35,000, but the directors were satisfied that the capital represented in the enterprises in which they had shares was well worth the money they had paid or might have to pay. The investments were taken at cost, and even in these depressed times the amount at which they stood could be easily realised.

The report was adopted, and a dividend of 40 per cent. for the half-year, making 25 per cent. for the year, was declared on the ordinary shares, and of £30 on each of the founders' shares.

REUTER'S TELEGRAM COMPANY, LIMITED.

The ordinary general meeting of Reuter's Telegram Company, Limited, was held on Wednesday at the Company's offices, Old Jewry.

Admiral Sir J. C. D. Hay, who presided, expressed regret that the subscriptions to their various news services in India, the Straits, and China, and elsewhere, being paid in silver, they had lost considerably by the decline in the value of the rupee and dollar respectively. The loss due to this cause would be apparent when he reminded them that the difference between 1s. 6d. a rupee, the rate current when their contracts were entered into, and the actual rate meant a loss to them in India and the Straits alone of about £2,000 per annum. The partial paralysis of trade arising from the same cause had reacted on their business in other departments. They did not fail at once to make the necessary changes, and hoped that the fresh arrangements would improve their position before the end of this year. Large outlays were rendered necessary by the protracted civil war in Brazil, the troubles in Argentina, and the Matabele campaign, not only in telegrams, but also in obtaining the information embodied in them. The accuracy and promptitude of their service regarding these matters had been generally recognised, and he was happy to be able to inform them that they now enjoyed a larger measure of support from the Press than they had done at any previous period of their history. They were put to a great deal of unexpected expense last year owing to the action of a news organisation in the United States with whom they had a contract for some time. They had been saddled with heavy outlays, which considerably swelled the amount figuring in the accounts under the head of expenses. This matter was now before the Courts, and they hoped to obtain compensation for the loss they had sustained. After stating that their present arrangements in America were most satisfactory, he moved the adoption of the report, which was seconded by the **Hon. Mark F. Napier, M.P.**, and carried.

HOBART ELECTRIC TRAMWAY COMPANY, LIMITED.

The first annual general meeting of the Hobart Electric Tramway Company, Limited, was held on Wednesday at the offices, College-hill-chambers, Cannon-street, E.C., Mr. G. D. Mackay presiding.

The **Chairman** said: The Company was registered on March 4, 1892, and our report is for the period to December 31, 1893. You will recollect that under the contract with the original company it was provided that the vendor company should complete the lines to the satisfaction of this Company, and hand over the same in time to enable Messrs. Siemens to commence the running by January 1, 1893, and by the contract with Messrs. Siemens it was provided that the lines should be open for public traffic by that date. Instead of opening the line on January 1, 1893, we were unable to do so. After the plant had arrived in Tasmania, a difficulty arose with the Government at the instance of the local telephone company, which alleged that our service would interfere with theirs. This difficulty proved to be serious, and involved protracted delay, but eventually it was amicably adjusted under an agreement by which our overhead wires were placed so as not to interfere with those of the telephone company. The service was opened on September 21 last, and the tabulated statement in the report shows with what result, there being a surplus after providing for the charges of maintenance. Under Messrs. Siemens's contract they undertook to work the line for 12 months from December 31, 1892, at 4d. per car mile, receiving not less than £1,000 per month, including in same wages of conductors, drivers, and of all the necessary maintenance staff. By a subsequent arrangement with Messrs. Siemens they undertook to work the line to March 31 last, on which date we took the maintenance into our own hands, having, with Messrs. Siemens's concurrence, entered into an agreement with their Mr. Parker to supervise the running. Under this arrangement we know that there will be a considerable annual saving. We consider ourselves fortunate in having secured the services of Mr. Parker, who acted as Messrs. Siemens's engineer during the period of construction. Referring to the balance-sheet, you will observe that no revenue account has been submitted. We propose that all payments and receipts to December 31 last be put to capital account, and that the revenue account shall commence as at January 1, when it might be held the Company had really a start. In next year's statement a profit and loss account will be submitted. I now move the adoption of the report and balance-sheet.

Mr. A. Mattei, LL.D., seconded the motion, which was carried.

BUSINESS NOTES.

Bristol.—The Electrical Committee of the Town Council held a short meeting on Friday last.

Western and Brazilian Telegraph Company.—For the past week the receipts were £2,401.

Romsey.—Complaints have been made in the Town Council regarding gas lighting of the streets.

Central Chili Copper Company, Limited.—This Company has been registered with a capital of £255,000

City.—A new block is being added to the City of London School. It is to be lighted by electricity.

Liverpool Rubber Company, Limited.—This Company has been registered with a capital of £123,117. 10s.

Pupil.—Mr. W. Claypole will shortly have a vacancy at the Phœnix Electrical Works, Derby, for an articled pupil.

Removal.—Messrs. Bolton, Fane, and Co. have removed to West India House, 98, Leadenhall-street, London, E.C.

Liverpool Overhead Railway.—The traffic receipts of this railway for the week ended 24th inst. amounted to £820.

Llandudno Electric Supply Company, Limited.—The capital of this Company, to which we referred last week, is £15,000 in £10 shares.

Appointment Open.—As will be seen from our advertisement columns, a firm of engineers want an electrical engineer to design dynamos and motors.

Electrical and General Investment Company, Limited.—The warrants for the dividends on the ordinary and founders' shares have been duly posted.

Messrs. J. Crossley and Sons.—The directors of John Crossley and Sons, Limited, have declared an interim dividend of 2s. 6d. on the ordinary shares.

Sale of Patent Rights.—Messrs. H. F. Joel and Co. offer for sale the patent rights of their alternating motor for France, Belgium, and the States.

Hemming and Co., Limited.—This Company is being formed to acquire the business of Messrs. T. L. Hemming and Co., Limited, of Snow-hill, Birmingham.

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Leeds Tramways.—The Leeds Corporation Tramways Committee arrived in Edinburgh on Tuesday, for the purpose of obtaining information as to the cable tramways.

Ship-Lighting.—The Union Steamship Company's new steel twin-screw steamer "Guelph," which has been built at Messrs. Harland and Wolff's yard at Belfast, is to be fitted with the electric light.

India Rubber and Gutta Percha Company.—The directors of the India Rubber, Gutta Percha, and Telegraph Works Company, Limited, recommend an interim dividend of 5 per cent., or 10s. per share, tax free.

Edison and Swan Company.—The Edison and Swan United Electric Light Company, Limited, will on August 27 next remove into their new premises, Ediswan-buildings, 36 and 37, Queen-street, Cannon-street, E.C.

Catalogue Received.—Messrs. Howard B. Little and Co., 20, Eldon-road, Kensington, W., send us a list of specialities manufactured solely by them. These comprise ringing bells, invalid or portable bell sets, medical coils, and sundries.

Oriental Telephone and Electric Company, Limited.—Notice is given that the first ordinary general meeting of this Company will be held on Wednesday, July 4, 1894, at 1 o'clock p.m., at Winchester House, Old Broad-street, London, E.C.

Cork.—The subscription list of the Cork Tramways Company, Limited, was opened on Saturday last, and will close to-morrow. The capital is £25,000. The tramways authorised will have a total length of 3½ miles, and there is power to adopt either electric or horse traction.

Ronald A. Scott, Limited.—This Company has been registered by H. W. Reeves and Son, Temple, with a capital of £10,000 in £1 shares, to acquire the business carried on by Mr. R. A. Scott at Acton Hill, W., and to carry on business as electrical engineers and electricians.

Eastern Extension, Australasia, and China Telegraph Company.—The directors of the Eastern Extension, Australasia, and China Telegraph Company, Limited, have declared an interim dividend for the quarter ending March 31 of 2s. 6d. per share, free of income tax.

Lancashire Boilers Required.—As mentioned in our last issue, the London County Council invite tenders for two new Lancashire boilers and fittings at the Council's Central Works, Belvedere-road, Lambeth, S.E. No tenders will be received after 10 a.m. on Monday, July 2.

Patents Pioneer Syndicate, Limited.—This Company has been registered with a capital of £10,000 to carry on business as bankers, capitalists, etc., especially in relation to dealing with inventions and letters patent; also as mechanical, civil, and electrical engineers, etc.

Aberdare.—The Examiners of the House of Commons have certified for second reading a provisional order made by the Board of Trade, enabling Messrs. J. C. Howell, Limited, to supply electrical power at Aberdare. The order has already passed through the House of Lords.

Electrical Engineer Required.—The Vestry of St. John, Hampstead, want an electrical engineer to take charge of their station, at a salary of £200. He must have practical experience of alternating-current central-station work. Application is to be made not later than by Monday next.

Wakefield.—The Wakefield electric lighting order, empowering the Wakefield Corporation to manufacture and supply electricity within the city of Wakefield, has come before the Examiner of Private Bills at the House of Commons, who certified that the Standing Orders had been complied with.

The Nova Scotia Cable.—Reuter's Agency states that information received by the Commercial Cable Company from the "Faraday" on Tuesday, gave the position at lat. N. 49 45, long. W. 43 36. Cable had been paid out to the extent of 1,338 miles. All were well, and the insulation of the cable was perfect.

City and South London Railway.—The receipts of the Company for the week ended June 24 were £863, against £765 for the same period last year, or an increase of £98. The total receipts for the first half-year of 1894 show an increase of £817 compared with those for the corresponding period of 1893.

Windsor.—Messrs. Roger Dawson, Limited, are carrying out the electric lighting of Clewer Park, the residence of Sir H. D. Gooch. They are installing about 100 lamps, with steam-engine, dynamo, and accumulators. The work is being carried out under the superintendence of Mr. A. E. Farrow, their Windsor manager.

Salt Lake Electric Light Company.—The Gas, Water, and General Investment Trust, Limited, notify that the coupons of the Salt Lake and Ogden Gas and Electric Light Company's first mortgage 6 per cent. bonds due July 1 next will be paid at the National Provincial Bank of England, Limited, Bishopsgate-street, on and after July 2.

Tenders for Lambeth.—Tenders are invited by the Lambeth Guardians for (1) two Galloway boilers and engineer's work, and (2) new smoke shaft and builder's work, at their workhouse, Renfrew-road. Forms of tender may be obtained and the specifications, drawings, and drafts of contracts may be inspected at the offices, Brook-street, Kennington-road. Tenders are to be sent in by July 4.

Lighting of the Big Wheel.—Messrs. J. G. Statter and Co., Limited, have received the contract for the electric lighting of the gigantic wheel at the Earl's Court Exhibition. The order is for the generating plant, the lighting of the 40 cars on the wheel, and the illumination of the wheel itself with 160 lamps. The whole installation is for 280 lamps.

Northern Engineers' Supply Company, Limited.—This Company has been registered with a capital of £3,000 in £5 shares to carry on business as dealers in all articles and goods required by or usually supplied to ironfounders, mechanical engineers, railway companies, etc. The first directors are Sir W. H. Bailey, Kt., J. Frankenburg, A. Bailey, and James Tinto.

Mill-Lighting.—The Leeds Association of Engineers visited Burley-in-Wharfedale on Saturday and inspected the Greenholme Worsted Spinning Mills. The lighting is entirely by electricity, about 2,000 lamps being employed. The electric plant was designed by Mr. Wilson Hartnell, of Leeds, and the dynamos, etc., were supplied by Messrs. Crompton and Co.

Salisbury Electric Light and Supply Company, Limited.—This Company has been registered with a capital of £20,000 in £1 shares to produce and supply electric current for light or power in the city of Salisbury. The first directors—to be not less than three nor more than six—are to be elected at a general meeting. Qualification, £250. Remuneration, £50 each per annum.

Liverpool.—The Watch Committee have received a letter from the solicitors to the Liverpool Electric Supply Company, giving formal notice of the company's intention to apply for a provisional order to supply electricity for public and private purposes in various parts of the city, including Queen-street, Oldhall-street, Devonshire-road, Springfield-street, and the Goree Piazzas.

Telephony to the Fair Isle.—Telephonic materials are being despatched from Kirkwall by the steamer "Fawn" to the Fair Isle, which lies midway between Orkney and Shetland, to be used in connection with the scheme for instituting telegraphic communication between lighthouses and the coasts. A telephone line is to be constructed between the lighthouse and the south of the island.

Tenders for Wolverhampton.—As notified in our advertisement columns, the Lighting Committee of the Corporation of Wolverhampton invites tenders for the supply of electric fittings suitable for the Town Hall, Art Gallery, School of Art, Free Library, and Market Hall; and for the electric wiring and erection of selected fittings. The Corporation is open to receive applications for a working foreman engineer.

Reuter's Telegram Company, Limited.—The report of this Company for the year ended December 31 shows, after payment of charges and deducting rebate on unexpired subscriptions, a debit balance of £2,767. The expenditure occasioned by the war in Brazil, the troubles in Argentina, and the Matabele campaign, together with the losses sustained owing to the fall in the Eastern exchanges, are said to explain the unfavourable results of the year's working.

Dewsbury.—Mr. Wm. Newsome, pianoforte manufacturer, of Ravensthorpe, is erecting new buildings at the junction of Croft-street and Bond-street, to serve as shops and offices. He has decided to have them lighted by electricity. The installation will consist of a 100-light dynamo, four arc lamps, and 72 16-c.p. incandescent lamps, and a 6-h.p. gas-engine fixed on the premises. The order has been placed with Messrs. A. Hirst and Son, electrical engineers, Crescent Works, North-street.

New Firm.—Mr. G. E. Piggott, who has for some years acted as representative for Mr. R. Applegarth in his electrical supply business carried on at 11, Queen Victoria-street, E.C., has resigned his connection with that gentleman, and commenced operations in the wholesale and retail electrical supply trade at 110, Cannon-street, E.C., under the name of Piggott and Co. We cordially hope that the new firm will prosper as much as the undoubted industry and ability of its head would merit.

Plymouth.—At the House of Commons the Bill confirming a provisional order of the Board of Trade conferring powers on the Corporation of Plymouth for the electric lighting of the borough has been before Mr. Thoms, one of the examiners of private Bills, for the investigation of the necessary Standing Order proofs after its first reading in the Commons. Mr. Woodward, of the firm of Sir Richard Wyatt and Co., appeared for the Board of Trade, and submitted proofs and evidence which satisfied the examiner that the Standing Orders of Parliament had been complied with.

Tenders for West Ham.—Tenders are invited for the electric lighting at the Public Hall and free library, Barking-road, Canning Town, E., for the West Ham Town Council. Specification, form of tender, and further particulars, may be obtained at the office of Mr. Lewis Angell, borough engineer, Town Hall, Stratford, E. Tenders, endorsed "Tender for Electric Lighting," are to be sent to Mr. Fred. E. Hilleary, town clerk, Town Hall, West Ham, by 4 p.m. on July 10. The contractor will be required to enter into a bond with two sureties for the performance of the contract.

Cardiff.—A special meeting of the Lighting Committee of the Cardiff Corporation was held on Monday at the Town Hall to appoint four engine fitters at the new electrical engineering works. The 10 candidates who, as we stated last week, were selected at a previous meeting out of 120 applicants to appear before the committee attended. Their testimonials having been read and the applicants examined by the members of the committee as to their experience and ability, the following were appointed to fill the positions: Messrs. Arthur Knight, W. S. Melhuish, D. W. John, and F. A. Parker.

Barnet.—At a meeting of the Local Board, a letter was read from Messrs. Crompton, thanking the Board for a copy of its resolution of the 5th inst. (recorded in our issue of 15th inst.), and stating that they would be glad to know when it was convenient

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for the committee to meet a representative of the firm. Mr. A. W. Fereday, hon. secretary of the Barnet Ratepayers' Association, wrote enclosing a copy of a resolution passed by the association on the 14th inst., with only one dissentient: "Seeing that the Local Board is negotiating for the introduction of the electric light, this meeting hopes that the Board will accept no scheme which will involve any charge on the rates for the purpose of a speculation in electric light." Both letters were referred to committee.

Leeds.—The Lamp Committee of the Leeds Corporation have had before them a letter from the Yorkshire House-to-House Electricity Company, requesting the committee to consider the desirability of illuminating some of the streets in the centre of the city with the electric light. In order that there might be a fair trial, the company offered to supply the electric current for any number of arc lamps up to, say, 30 on the line of mains at 4d. per unit net. The committee, however, felt that the proposal was somewhat untimely. It was pointed out that they had recently spent a large sum of money in fixing Bray's lamps in the principal streets, and would scarcely be justified in going to further expenditure at present. The letter was therefore ordered to lie on the table.

Bolton.—Since the work of constructing the transforming centres in connection with the Bolton electric lighting undertaking was commenced, public interest in this important work has been considerably developed, and enquiries are very frequent as to how soon the Gas Committee will be ready to supply the new illuminant. Since the decision of the Town Council to supply consumers with the requisite fixtures on an easy payment system, applications for a supply of electricity have considerably increased. The works at Spa-road are being rapidly pushed towards completion; the three boilers have been some time in position, and the boiler-house is now in process of being roofed in. Other portions of the building are in an equally forward state, and its chimney has reached the intended height, and now only awaits the ornamental coping stone to complete it.

Dundee.—Mr. Brownlee, the electric lighting engineer, has recommended that the works be extended by the introduction of a 200-h.p. engine with dynamo. At present the station has 660 h.p., and, with the addition, it will have a capacity of about 1,800 lights. This will be sufficient for the ensuing winter, but it is anticipated a further extension will be required in the succeeding year. The Works Committee of the Gas Commission have arranged to have two electric lamp-posts placed in front of the new offices in Commercial-street. The Gas Commissioners have resolved that the electric light be supplied at 5d. per unit. According to the convener of the Finance Committee of the Gas Commissioners, the deficit on the electrical department, amounting to £1,721, has been wiped off out of the gas revenue. There are now 186 electric light consumers, with 5,293 16-c.p. lamps.

Electric Lighting in St. Pancras.—The total income of the St. Pancras Vestry in respect to electric lighting has been £15,022 during the year. This sum is sufficient to clear off the deficit of the first year—£1,543—and after paying all the working expenses and £927 in maintaining the works, a balance of £4,669 is left, out of which interest and repayment of loans have to be met. The tender of Mr. J. O. Richardson, of Peckham, was accepted for the erection of the main buildings, boundary walls, etc., of the King's-road station at £5,178. The Electricity Committee reported that Messrs. Kelly Bros. were communicated with respecting the employment of London men in executing the work of building the main central-station buildings, but they stated that they could not put themselves under any restrictions as to the men employed, and withdrew their tender. The committee have therefore decided to invite fresh tenders.

Worcester.—The Mayor of Worcester (Mr. G. H. Williamson) moved, at a meeting of the Town Council, a recommendation of the Watch Committee that the price for the electric light should be fixed at 5d. per unit. This figure would yield a very handsome profit in reduction of the rates, if the power they were providing was taken advantage of by the citizens. He pointed out that they were utilising the water power of the Teme, which would be of great assistance in making the installation a profitable one. Electric pumping machinery was going to be fixed at the waterworks for raising water to the higher levels, which would, as compared with steam machinery, effect a saving of £600 a year. If they could only calculate on 600 h.p. being used for four hours a day for 300 days in the year, there would be, at 5d. per unit, a revenue of £7,500. The present investment in the works was £46,000. The motion was agreed to.

Bournemouth.—We reported in our "Notes" last week that Mr. F. H. Tulloch had held a Local Government Board enquiry into the proposal of the Town Council to borrow £4,000 for the purposes of the electric lighting of the pier and gardens. In connection with this and allied matters the Council have approved of the following items in the report of the Electric Light Committee: "The surveyor's report on the power at his disposal for electric lighting purposes was read, from which it appeared that a saving of £150 a year might be effected by the Council lighting the winter garden. The committee recommended that the report be laid before Mr. E. M. Lacey, electrical engineer, under the resolution of the Council. The committee recommended that the town clerk write the electric supply company asking if they would be prepared to make any (and what) reduction in the cost of lighting the winter garden under an agreement for a term of years."

Glasgow.—At a meeting of the various municipal trusts, the return asked for by Mr. W. F. Anderson as to the telephonic connections rented by the Corporation and the several trusts from the National Telephone Company, Limited, and the rentals paid therefor, was submitted. It showed that there were 31 connections in all, and the rentals paid by the various departments were: Corporation, £21; municipal buildings, £173. 10s.; improvements, £34. 10s.; markets, £25; parks, £15; Contagious Diseases (Animals) Acts, £40. 5s.; water, £9; and gas and electric lighting, £178. 15s.; a total of £497. The Glasgow Water Commissioners decided to enter into a five years' agreement with the National Telephone Company for a telephonic connection between their office in John-street and Strathblane, with loop lines to the other stations belonging to the Commissioners between these two places, and also to Maryhill, for a sum of £93 per annum.

Tenders for Edinburgh.—Tenders are invited for the following in connection with the electric lighting of the city, for the Corporation: contract No. 6A, supply of cast-iron road boxes; contract No. 10, supply of copper strip connectors, etc.; contract No. 11, supply of gunmetal grip-boxes; contract No. 12, supply of cable connectors and cones. Copies of any of the specifications and drawings can be obtained from the resident electrical engineer, City Chambers, Edinburgh. All information will be supplied by Prof. A. B. W. Kennedy, consulting electrical engineer to the Corporation, 14, Old Queen-street, Westminster, London, S.W., and by Mr. E. W. Monkhouse, resident electrical engineer, City Chambers, Edinburgh. Firms wishing to obtain copies of any of the specifications must send with their written application a deposit of 10s. 6d., which deposit will be returned on receipt of a *bonâ fide* tender. Tenders are to be directed to Mr. Wm. Skinner, W.S., town clerk, City Chambers, Edinburgh, and must be received in Edinburgh not later than July 4.

Lighting of Bradford.—The town clerk mentioned at a meeting of the Council on Wednesday that there was a matter to which it was necessary to call attention, the Electricity Committee stood in need of some new boilers, the cost of which was £2,875. The committee were anxious to have two boilers which were now ready, but it was necessary to have the sanction of the Council before the boilers could be received. In order to save time the Council were asked to deal with the subject at this special meeting. The boilers were supplied by Messrs. Thwaites Bros., Limited, of Bradford, and were described as two marine boilers, fitted with Ellis and Eaves's system of induced draught. Alderman Moulson, chairman of the Gas and Electricity Supply Committee, said the Council determined some months ago that tubular boilers should be obtained for the electricity works, and they had now been obtained. It was very necessary that the new boilers should be got in before winter came, and if the Council gave the necessary power that afternoon they could be laid by about October. He proposed that the action of the committee with respect to the purchase of the boilers should be confirmed. The motion was seconded, and after some discussion it was adopted.

Aberdeen.—At a meeting of the Education Committee of the Governors of Gordon's College, tenders for the fitting up of appliances for lighting the college by electricity were submitted. Twenty-six contracts were tabled, and, without going into them, the committee handed the offers to the convener and Mr. Murray, electrical engineer, with a request that they should schedule them, so that they might be considered at a future meeting. A discussion has taken place in the Town Council as to whether, in addition to electric light fittings, gas-pipes should be inserted in the new police buildings. Mr. Young and others argued that such a proposal was unnecessary, and showed want of confidence in the electric light. Bailie M'Kenzie stated that the proposal was made on the advice of Mr. Ruthven Murray, but he agreed that the committee should reconsider the matter. At a meeting of the Gas Committee of the Council on Tuesday, it was resolved to recommend that the price to be charged for lighting the streets by electricity should be 3¾d. per lamp per hour, and that the Street Department have the entire control of the lamps, except in the case of a sudden breakdown. A question was put to Mr. Murray, electrical engineer, with reference to a statement made at Monday's meeting of the Council to the effect that he had said that gas-pipes would be required to be laid in the new police buildings, which it had been resolved to illuminate with electricity. Mr. Murray said that he had been misunderstood with regard to the matter, and that he never did, and never would, advise gas fittings and pipes to be introduced into a building into which the electric light was to be put. The object of the question was to prevent a statement going out which would mislead anyone intending to adopt the electric light to think that gas would be necessary.

Lighting of the Embankment.—At last Tuesday's meeting of the London County Council, the Works Committee reported that in accordance with the reference from the Council they had considered the estimate and specification submitted by the Highways Committee for the erection of a generating station for the electric lighting of the Victoria-embankment and the Westminster and Waterloo Bridges. They reported in accordance with standing orders that they were not satisfied with the estimate, and recommended that the estimate be referred back to the Highways Committee. With respect to the same station the Highways Committee at the same meeting reported: "The Council on June 5 resolved that the generating station for the electric lighting of the Victoria-embankment and the Westminster and Waterloo Bridges should be constructed without the intervention of a contractor; and the plans, specification, and estimate were referred to the Works Committee for that purpose, with an instruction that the work should be carried out with all possible expedition. We have received an intimation from that committee of its intention to report to the Council on Tuesday next that the estimate is not sufficient; but, having again given very careful consideration to the estimate, we are of opinion that the amount

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is adequate, and we should therefore not be justified in increasing it. In the circumstances we think the best course would be to submit the work for public competition; and we recommend that the resolution of the Council of June 5, 1894, which directs that the generating station for the electric lighting of the Victoria-embankment and the Waterloo and Westminster Bridges shall be constructed without the intervention of a contractor, be rescinded, and that tenders for the execution of the work be invited by public advertisement."

Fareham.—At a meeting of the Fareham Local Board it was determined by the casting vote of the chairman that an offer should be made to the electric light company to purchase the undertaking for £5,000, an additional £1,000 being allowed for laying the wires underground. The following are the details of the agreement: The sum of £5,000 to include the buildings (on land held on lease), together with all the plant, machinery, mains, meters, and all other electrical and mechanical appliances appertaining thereto, as entered in and shown by the books of the company, together with the benefit of their provisional order. The Browett-Lindley compound vertical engine not to be included in the above-mentioned sum of £5,000, but to be for the credit of the company to provide another engine as herewith mentioned. The company further undertake to execute the following works for the additional sum of £1,000: (1) To lay underground (as provided for by section 82 of the provisional order) the electric lines in the streets and parts of streets as follows: Gosport-road from the electric light depôt to the junction with South-street (Quay-street), South-street, West-street from a point opposite Trinity Church to the junction with High-street, and High-street from its junction with West-street to Wallington Hill. (2) To provide a new engine of equal capacity to the horizontal compound engine by Ransomes, Sims, and Jefferies, now in use. The company also agree that, provided the above works be carried out for a less sum than the before-mentioned sum of £1,000, the Fareham Local Board shall receive credit for any such sum; on the other hand, any excess over and above £1,000 shall be paid by the company. It was arranged that, pending the application to the Local Government Board for permission to borrow the necessary loan, the clerk should see to the preparation of the contract for the purchase of the electric works, and that it should be considered either at a special meeting or at the next ordinary meeting of the Board.

Newcastle.—Messrs. Bainbridge and Co., of Market-street and Bigg Market, Newcastle, are making some very extensive alterations, and considerably extending their premises, which necessitates a complete rearrangement of their motive power plant, and many additions thereto. This has been placed in the hands of Messrs. Thos. Beecroft and Co., engineers, Leeds, and the contracts for the work comprise one Lancashire boiler 20ft. by 7ft., to supply the steam to a new horizontal engine fitted with patent automatic triple-expansion gear, and giving off 75 effective horse-power. This boiler also supplies the steam for heating the premises. There is also a compound Robey engine and boiler of 125 effective horse-power, which is used for electric lighting exclusively. The engines, boilers, etc., are being made by Messrs. Robey and Co., Limited, Lincoln. The whole of the electrical work is being carried out by Messrs. Ernest Scott and Mountain, Limited, Close Works, Newcastle, on a most extensive and elaborate scale. This portion of the work includes one of their latest dynamos, capable of running 1,000 16-c.p. lamps. There is also another dynamo for running 300 16-c.p. lamps, electric motors, etc. These are for day service, and are driven by the 75-h.p. engine. When completed the whole will form one of the largest electric light installations in the North of England. Messrs. Armstrong and Knowles, of Newcastle, are the architects, to whose plans the whole of these alterations are being carried out. Messrs. Scott and Mountain have also a considerable amount of pumping work, etc., in hand. For Messrs. G. B. and T. E. Forster, mining engineers, Newcastle, they are finishing a complete set of electric pumping plant, consisting of Corliss engine, 60-unit dynamo, and seven sets of pumping machinery, to take the place of the existing wire-rope pumps. For Messrs. Straker and Love, Brancepeth Colliery, County Durham, a set of pumping machinery, to deliver 300 gallons of water per minute against a head of 420ft., with engines, etc.

Birkenhead.—An enquiry was held on Tuesday at the Town Hall by Mr. Rienzi Walton, M.I.C.E., one of the Local Government Board inspectors, into an application by the Birkenhead Corporation to borrow £35,000, of which £20,000 is for electric lighting. The Town Clerk, Mr. A. Gill, represented the Corporation, and said the loan of £20,000 for electric lighting was made up of two different items. The first was £1,576 in respect of 3,152½ yards of land in Bentinck-street for a site for the central generating station. The Corporation had entered into a provisional agreement to purchase the land, which was really the only suitable site in the borough. The second item was £18,424 for the erection of works, and in respect of this the inspector might possibly withhold his certificate, because at the present moment the Corporation had not really approved of the plans prepared by Mr. Shoolbred. The site which they had secured was more than sufficient for the scheme proposed for the present, but was not too large for the full carrying out of the electric lighting order. Alderman Deakin said that the price of the land was 10s. per yard, which was very moderate. The gentleman who owned the land, knowing the purpose for which the Corporation required it, had come forward with great public spirit and sold it at a considerable sacrifice to himself. The Town Clerk said, in regard to the erection of works, that Mr. Shoolbred had submitted an alternative plan, showing a greatly improved building at an extra cost of £2,000, but the Finance Committee did not see their way to approve it. The Corporation were not in a position to submit the details, but they were practically agreed that they would have to build a boiler-house, workshops, chimney, etc. The inspector said he would proceed with the enquiry as usual, and would hold over his report until he got a subsequent notification from the Corporation. If they then approved of the plans, his report would hold good, and if not it must be left to the Local Government Board. Mr. Shoolbred then gave detailed evidence of the scheme.

A Police Court Case.—At Bow-street Police Court on Wednesday Mr. Lawrence Henry Bloomfield, electrician, of Queen Victoria-street and Richmond, appeared to a summons charging him with obtaining by false pretences £120 from Richard Lonsdale. Mr. Purcell appeared for the complainant, and Mr. Travers Humphreys for the defendant. Mr. Purcell said that he wished to withdraw the summons. The facts of the case did not warrant all that was set forth in the information, and there was reason to believe that there had been no intention to defraud. Mr. Vaughan said that, according to the information, there was a *primâ facie* case, and the matter must be explained. Mr. Humphreys said that, according to the information, the complainant was told by the defendant that he had secured a contract with the Brighton and Hove Electric Light and Supply Company. The complainant contended that the defendant had not secured such a contract. As a matter of fact, the defendant had not secured it; but he was in communication with a man named Stevens who promised to secure it for him. The defendant borrowed money from the complainant for the purpose of buying electric lamps in Germany, and, as a matter of fact, he went to Germany and made purchases there. Mr. Vaughan said that the complainant had better give evidence, and then Stevens ought to be called. The complainant stated that he was an electrical engineer carrying on business in the Strand. Last year the defendant said he was an agent for a Dutch firm of electric lamp makers, and the complainant agreed to supply him with money for the purchase of lamps. In February last the defendant said that he had secured a contract with the Brighton and Hove Electric Lighting Company. Limited. Believing this to be true, the complainant advanced him £120 to enable him to go abroad and purchase lamps. In reply to the magistrate, the complainant said that the defendant told him he had secured the contract through another man, although he made no mention of that in the information. Mr. Vaughan said that in the face of that admission it would be useless to proceed further. The other man referred to might have made a false statement to the defendant as to the Brighton and Hove contract. There appeared to be no intention to defraud, and the case would be dismissed.

Salisbury.—Another important step has been taken towards the supply of electricity in Salisbury by a public company. When the consent of the Town Council to the application for a license was sought last month by Mr. W. H. Gramshaw, it was pointed out by that gentleman that, to prevent the enterprise being delayed, it was necessary that the sanction of the Salisbury Corporation should be obtained and notice given of application to the Board of Trade before July 1. After twice considering the matter at special meetings, the Town Council unanimously consented to Mr. Gramshaw's request; and notice has been given of an application to the Board of Trade, under the Electric Lighting Acts, for a license to enable the Salisbury Electric Light and Supply Company, Limited, to produce and supply electricity for public and private purposes within the city. The streets and parts of streets comprising the area within which the company propose to lay electric mains are: Fisherton street from the railway bridge eastwards, Bridge-street, Silver-street, Butcher-row, High-street, Minster-street, Blue Boar-row, Castle-street from Blue Boar-row to Chipper-land, Endless-street from Blue Boar-row to Chipper-lane north side, Winchester-street from Blue Boar-row to the east corner of Rollestone-street, Milford-street from Catharine-street to the corner of Brown-street, the Canal, New-street, Catharine-street, Brown-street from the corner of Winchester-street to the corner of Milford-street, the Close within the Close wall, St. Ann's-street as far as the borough boundary on the Southampton-road, St. John-street, and Queen-street. The above streets form the compulsory area, but outside this there is, as Mr. Gramshaw explained to the Town Council last month, a voluntary area comprising the remainder of the municipal borough. Within the compulsory area the company must lay distributing mains within one year after the acquisition of the license, but as regards the voluntary area, it is at their discretion to extend their supply to any part of it or not, and of course the extension would depend upon the opinion formed by the company whether a supply was likely to prove remunerative or not. Mr. Alex. J. Murray, 1, Clement's-inn, London; Messrs. Macdonald and Malden, Salisbury; and Sherwood and Co., Great George-street, Westminster, are the solicitors.

Dublin.—Particulars have been obtained from Mr. Spencer Harty, C.E., city engineer and surveyor, Dublin, by the *Western Mail* as to the experiences of the Corporation in connection with the introduction of the electric light. Mr. Harty says: "In reply to your enquiry as to our experience of electric lighting, I have to say that the installation by this Corporation has been most successful. The price paid for gas in Dublin is 3s. 7d. per 1,000 cubic feet, and the charge for electric light is 7d. per Board of Trade unit (less 7½ per cent. on quarterly accounts over £100, and 5 per cent. under £100, if paid within two months). These figures will give you an idea of the relative cost, but it must be borne in mind that the action of gas on interior decorations of houses, libraries, fine goods in warehouses, etc., is very detrimental, and these considerations must be taken into account in estimating the relative cost

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of the two lights. It certainly would be unfair to the electric light system to ignore its advantages in this respect, and to take the figures of the cost in the abstract, for purposes of comparison. I am satisfied that hotels, clubs, theatres, and such buildings, containing costly decorations, as well as for warehouses stored with fine goods, the electric light will be found of greater advantage. On the question of profits, our working for the first year, ending December 31 last, shows a surplus of £1,545, which would represent a dividend of about 4½ per cent. per annum on the amount of capital remaining due at the close of the year. I cannot say to what extent the consumption of gas has been affected by the electric light, as the gas undertaking is not controlled by the Corporation. The number of incandescent lamps on the electric light installation is equivalent to 14,000 8-c.p. lamps, and we have 81 arc lamps in the thoroughfares. I send you a copy of a pamphlet descriptive of the works, which was published soon after the introduction of the light. Since then, however, we have introduced plant for day-load lighting, and in response to pressing applications for the light are now engaged on a further extension of the works." The Dublin pamphlet enables customers to estimate the cost. Thus a lamp of 16 c.p. consumes 65 watts and a lamp of 8 c.p. 40 watts per hour. If there be installed in a house 30 lamps of 8 c.p., and the average number of hours in the year during which those lamps are burnt is 500, the average consumption of units would be as follows: Thirty lamps, each of 40 watts—1,200. One thousand two hundred watts multiplied by 500 hours give a result of 600,000 watt-hours, or 600 units. Up to 30 units the Dublin Corporation at present charge £1 per quarter; over 30 and up to 60 units, £2; over 60 units, 7d. per unit.

Edinburgh.—The question of the electric lighting of George-street and neighbouring thoroughfares has again been under the consideration of the Lord Provost's Committee of the Edinburgh Town Council, when a report from the engineers on the subject was directed to be referred to the Cleaning and Lighting Committee. On Monday last the Lord Provost laid the foundation-stone of the central electric light station in Torphichen-street. The installation which is in progress is the first for the supply of electric light for private purposes in Edinburgh, but 13 years ago there was an abortive experiment in public lighting. In June, 1881, the Town Council accepted an offer of the Anglo-American Brush Electric Corporation to light Princes-street, the North Bridge, and Waverley Bridge, for three months, at a cost of £389, with power to the Council to purchase the plant, at the end of the trial, for £2,407. The experiment did not give satisfaction, and at the end of the three months the plant was cleared away in December, 1881, the whole thing having cost the town £838. The Brush Corporation made application again in June, 1888, for permission to lay down mains in Rose-street-lane for the purpose of supplying electricity in Princes-street; but although the application was favourably reported upon, it was not given effect to. In 1889 six companies gave notice of their intention to apply for provisional orders, but the Town Council announced their intention of taking up the matter themselves, and in 1891 they obtained a provisional order. Prof. Kennedy was appointed consulting engineer, and he submitted a scheme. The station will have a frontage to Torphichen-street of 200ft., and to Dewar-place of about 150ft. It is built to accommodate about 17 boilers—equivalent to 6,000 h.p.—and about a score of engines and dynamos; but until the demand requires it, it is not proposed to put down more than six boilers and six engines and dynamos, which will be sufficient to supply an equivalent of 40,000 lamps of 8 c.p. Councillor Mackenzie, at the laying of the foundation-stone on Monday, said that it was proposed to light the compulsory area and a good portion of the New Town beyond that area, and plant would be put down in the central station sufficient to do so. They were, however, making provision in this central station for doing a great deal more than that, because, judging from what was taking place in other towns, there would soon be a much greater demand for the electric light than they could supply with the plant they were providing at present. They had, therefore, made the station large enough to meet practically the wants of the whole town, though it was not intended to supply the whole of Edinburgh by one system. There was considerable difference of opinion as to the merits of the high-tension and low-tension systems, and on the advice of Prof. Kennedy they were to light the central parts of the city with the low-tension system, and the districts with the high-tension. They hoped that before the end of the year they would be in a position to turn on the current. The Lord Provost, who also spoke, said that they were now within sight of the time when they should be able to give the electric light to every person who wished to pay for it. He desired to impart this piece of elementary information to them, for he found that the scheme was not well understood—that the primary purpose of the order was to supply the electric light to houses. The lighting of the streets with the electric light was a mere incident of the scheme. One effect of proceeding leisurely with the scheme was this, that they were able to tell the ratepayers how much the lighting of the streets would cost, so that they would be saved making a wry face when the bill came in. He did not think that gas was played out. He believed they would both be good servants—gas and electricity—in their own ways; for in the future he hoped to see gas used a great deal more for cooking and for motors. Hitherto their Edinburgh gas had been too expensive to make free use of it in such a way. Until lately their standard gas had been of 27 c.p. or 28 c.p., whereas in London it varied from 14 c.p. to 16 c.p. If they diminished the illuminating power they could supply it at a price which would induce people to use it for the purposes he had indicated, and those people who wanted a high light could go in to use the electric light. They were starting with a low price in Edinburgh for the electric light. They could charge 8d. per unit, but they were only to charge 6d., and those people who used large quantities would get it for 4½d. It was the interest of everyone who used the electric light to get others to do the same, because when their 6,000 h p. was in use they would likely be able to supply the light for a little over 4d. a unit. A dinner subsequently took place in the Council Chambers, and later in the evening Prof. Kennedy delivered a public lecture on the subject of the electric light in Edinburgh. He pointed out that the highest charge for current would be 6d. per Board of Trade unit. The lamps would cost 1s. 3d. each. In these circumstances the cost would be about a seventh of a penny per hour for an 8-c.p. lamp, and a farthing per hour for a 16-c.p. lamp. Each incandescent lamp would last 500 or 600 hours, giving effective light, so that in a private house, with gas at the present price, electric light ought not to cost more than gas. On Tuesday night Principal Grant Ogilvie made arrangements by which for an hour the fully-equipped electrical appliances at the Heriot-Watt College were thrown open to the public, with the view of giving those who cared to avail themselves of it an opportunity of seeing the method of applying electricity to illuminating purposes. The engines and dynamos used in the lighting of the college buildings were on view, as also were the electrical laboratories of the institution.

Electric Lighting of Hampstead.—In our issue of 15th inst. we recorded in our "Business Notes" the report of the Finance Committee of the London County Council, given on the 12th inst., on the subject of the loan to the Hampstead Vestry. At Tuesday's meeting the Finance Committee reported: "On the 12th inst. we reported on the application of the Vestry of Hampstead for sanction to the borrowing of a further sum of £25,000 on the instalment system, for electric lighting purposes, for 50 years, and recommended the Council to sanction the Vestry borrowing £23,500, to be repaid in 25 years Consequent, however, on the receipt of a letter from the Vestry on that day, asking that the matter might be further considered, the report was withdrawn from the Council. The Vestry state in their letter that they have entered into contracts in connection with this work for £20,080, and estimate the cost of further works at £1,425, making together £21,505. The details of these figures were given in the report, in which it was stated that the value placed on the works by the Council's engineer was £19,647. It has since been found that a clerical error was made in these figures by the omission of £848, which added to the £19,647 amounts to £20,495, and adding also £8,900, the value of the central supply station, chimney shaft, and offices as mentioned in the last report, there is produced a total of £29,395, and deducting the sum of £5,000 already advanced the sum of £24,395, or, say, £24,400, remains to be borrowed. The Hampstead Vestry urge that as the Council gave its sanction to the repayment by the Vestry of St. Pancras of the proposed loans of £60,000 and £15,400 in 42 years, they should be allowed the same period to repay their loan. The Council must, however, be reminded that these loans were sanctioned in December, 1891, and in July, 1893, before the Council was in full possession of the views of the Treasury upon this subject, and before the question of a depreciation fund for renewals had been considered in connection with these electric lighting schemes. The subject of the term to be allowed for electric lighting loans was fully reported upon to the Council on February 13, 1894, and considered, with the result that the sanction to the raising of the £15,400 by the St. Pancras Vestry, repayable in 42 years, was withdrawn, and consent given to the raising of £29,700 (inclusive of the £15,400) to be repaid in 25 years, and this period was passed by the Treasury in anticipation of the Vestry taking up the loan. The Vestry also state that they are in a better position than St. Pancras, inasmuch as they are erecting the works on their own freehold ground, whilst St. Pancras borrowed £10,000 to acquire a site for that purpose. It may, however, be mentioned that the Hampstead Vestry borrowed from the late Board in 1880 the sum of £4,000 to purchase two acres of land in the Finchley-road for the purposes of a stone and store yard, repayable in 49½ years—*i.e.*, by October 1, 1929—upon part of which land they now intend to erect their electric lighting works: there is consequently an outstanding charge on the site for 36 years yet to come. The main reasons adduced by the committee in recommending the term of 25 years on the last occasion were: (1) That in an undertaking of this kind a very large proportion of the initial cost is for short-lived purposes, and in this respect it differs from a street improvement and many other works. It may be mentioned that the Council has decided that the initial cost of its own installation of electric light on the Victoria-embankment should be repaid in 25 years. (2) That from the nature of the undertaking large sums must be expended for renewals of boilers, dynamos, mains, etc., at given periods in addition to ordinary maintenance repairs and small renewals, and that it would be practically impossible for the Vestry to pay these large sums out of the income of the year. The Vestry would be urged by the ratepayers of the day to apply for a loan to meet such heavy expenditure, and the Council would find it difficult to refuse its sanction. The Vestry do not apparently propose to establish a depreciation fund to meet these renewals, as an electric lighting company would do, and even if the Vestry did create such a fund the Council would have no power to see that it was kept up to a proper level. (3) That the term of 25 years being but slightly in excess of the equated period of the life of the work, will leave the Council and the Vestry a perfectly free hand as regards future borrowings which may become necessary to meet recurring expenditure for renewals, improved methods of generation or supply involving a large outlay, which it would be unreasonable to charge on the current rates.

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(4) That the term of 25 years is the one sanctioned by the Local Government Board for electric lighting loans—*i.e.*, for a complete installation, including the purchase of land in some cases. That many of the large corporations—such as Manchester, Bristol, Blackburn, Portsmouth, and Leicester—have borrowed on these terms, and are content to carry out their electric lighting schemes under these conditions, whilst the Council in addition gives, in the case of loans for sites, the longest period (50 to 60 years) for repayment. The Vestry contend that they should be allowed a longer period than one based on the life of the work, in order that they may be able to successfully compete with a company which does not have to pay off its capital; but even if this argument be admitted, it must be remembered that a company cannot raise its capital at 3½ per cent. as the Vestry can, and that a company has to establish a reserve fund to meet depreciation and other contingencies, so that the Vestry is not apparently placed at any disadvantage as compared with a company. We see no reason why the Council should go back from its decision of February 13 last as regards the term to be allowed for these electric lighting loans. The equated period in the case of Hampstead works out at 22 years, and the term of 25 years appears to us to be a fair one to allow. We therefore repeat our former recommendation, amended so as to cover the amount inadvertently omitted: '(*a*) That the sanction of the Council be given to the borrowing by the Vestry of Hampstead of the sum of £24,000 towards defraying the cost of an electric light installation in that parish, at a rate of interest not exceeding £3. 10s. per cent. per annum, and to be repaid by instalments of principal, or principal and interest combined, within a period of 25 years from the date of the loan; (*b*) that the seal of the Council be affixed to the order submitted with the report.'" In the discussion on the report of the Finance Committee, Mr. Benn, M.P., and others urged that the Council should give the vestries the advantage of the provisions of the Money Act of last year, which provided that the term might be 42 years. Mr. H. Harben moved an amendment to this effect, and it was carried by a large majority.

PROVISIONAL PATENTS, 1894.

JUNE 18.

11733. **Improvements in or appertaining to electrical railways or tramways.** Rudolf Altschul, 6, Lord-street, Liverpool.

11780. **Improvements in the means of distributing alternating electricity.** David Cook, 30, Lancaster-park, Richmond, Surrey.

JUNE 19.

11809. **Electrical life-preserving fire-alarm.** John Brafield Rolfe, 26, Burnt Ash-road, Lee, London.

11813. **Improvements in phonographs.** Frederick Woilliard-Rigg and Harry Ernest Scarborough, Wade-street, Halifax.

11814. **Automatic auxiliary electric block, and engine distance caution signal for railways.** William George Martin, Woodside Park Station, G.N.R., London.

11822. **A new attachment for hanging electroliers and other electric fittings.** Augustus Marsden, 18, Gironde-road, Walham Green, London.

11840. **An instrument for finding the direction of induced current, rotation, or magnetisation in an electric generator or motor.** John Willoughby Meares, Queen-street, Chelmsford.

11843. **To illuminate by electricity castings of flowers, fruits, and foliage taken from nature for the purpose of decoration in plaster either cornices, centre ornaments, entablature, etc.** Charles Gillard, High-street, Chard, Somerset.

JUNE 20.

11903. **Improvements on conduit electric systems for supply of current to tramway, rail, or other motors.** Arthur Alexander Govan, 15, Renfield-street, Glasgow.

JUNE 21.

11979. **Improvements in or relating to metal brushes for dynamos.** Wilhelm von Braucke, 16, Finkle-street, Stockton-on-Tees.

11995. **Improvements in testing and working electric telegraphs.** William Thomson (Baron Kelvin), 154, St. Vincent-street, Glasgow.

12006. **Improvements in iron clips for fixing electric light casing and other purposes.** Charles Bishop, 66, Byles-street, Toxteth Park, Liverpool.

12009. **An automatic electrical switch.** Wilfred Robert Vernet Marshall, Torrieburn, Barnes, London.

12045. **Improvements in secondary batteries.** Alexander Schanschieff, 191, Fleet-street, London.

JUNE 22.

12099. **Improvements in the construction of armatures for dynamo-electric machines and electric motors.** Henry Francis Joel, 44, Lavender-grove, Dalston, London. (Complete specification.)

12100. **Improvements in or connected with signalling electrically to locomotives or trains in motion.** John William Sunderland and George Bilbrough, 33, Chancery-lane, London.

12131. **Improvements in electric brake operating mechanism for vehicles.** Louis Eugene Freedley, 45, Southampton-buildings, Chancery-lane, London. (Dated applied for under Patents, etc., Act, 1883, sec. 103, December 29, 1893, being date of application in United States.) (Complete specification.)

12137. **Improvements connected with a combined walking-stick and electric lamp appliances.** Harry Newbold, 166, Fleet-street, London. (Complete specification.)

JUNE 23.

12140. **Improvements in electric igniters.** Alan Archibald Campbell Swinton, 66, Victoria-street, Westminster.

12147. **An improved electrical gripper bar, applicable to printing machines.** William Brewer Silverlock, 18, Fulham-place, Paddington, London.

12181. **Improvements in electrically-heated apparatus for use in soldering, brazing, and like operations.** Rookes Evelyn Bell Crompton, 55, Chancery-lane, London.

12183. **Underground electrical propulsion.** John Edward Parker, 1, Broad-street, New York, U.S.A.

12221. **Improvements connected with electrical furnaces.** Philip Middleton Justice, 55, Chancery-lane, London. (Edward Goodrich Acheson, United States.)

SPECIFICATIONS PUBLISHED.

1891.

3664. **Electrical switches.** Binswanger. (Second edition.)

1893.

10597. **Adapting electric lamps to candle fittings, etc.** Sluce.

10772. **Ceiling roses, etc., for electric connections.** Cutting.

12785. **Electric switches.** New and Mayne.

13749. **Electric elevators.** Smith.

14271. **Distributing electricity.** Bertram and Hope-Johnstone.

14533. **Supplying electrical energy to motor vehicles on electric railways, etc.** Siemens Bros. and Co., Limited. (Siemens and Halske.)

14715. **Electric bell pulls and pushes.** Harcourt.

15510. **Electric arc lamps.** Brookie.

16026. **Regulator for dynamo-electric machines.** Siemens Bros. and Co., Limited, and Holmes.

1894.

3072. **Arc lamps.** Woolverton.

8587. **Electric railways.** Lake. (Purvis and another.)

COMPANIES' STOCK AND SHARE LIST.

Name.	Paid.	Price Wednesday.
Birmingham Electric Supply Company	5	5¼-5⅝
Bournemouth Electric Company	—	
Brighton and Hove Company Original	100	210-215
—— "A" Ordinary	—	162-166
Brush Company, Ordinary	3	2⅞-3
—— Nom. Cum., 6 per cent. Pref.	2	2⅛-2⅜
—— 4½ Debenture Stock	100	109-112
Charing Cross and Strand	5	4¼-5¼
Chatham and Rochester	—	—
Chelsea Electricity Company	—	—
City of London, Ordinary	10	12½-12¾
—— 6 per cent. Cumulative Pref.	10	13¾-14¼
—— 5 per cent. Debenture Stock	75	87-90
City and South London Railway, Consolidated Ordinary	100	36-38
—— Debenture Stock	100	119-121
—— 5 per cent. Pref. Shares	10	12½-13
Crompton and Co., 7 per cent. Cum. Pref. Shares	5	2¾-3⅛
—— 5 per cent. First Mortgage Debentures—1-400 of £100 and A, 1-200 of £50.	100	96-100
Elmore's French Company	2	⅛-¼
Electric Construction, Limited	2	⅛-¼
—— 7 per cent. Cumulative Pref.	2	1¼-1½
Elmore's Copper Depositing	2	1-1¼
Electricity Supply Company for Spain	5	—
Elmore's Wire Company	2	¾-1⅛
Fowler-Waring Cables	5	¼-1½
W. T. Henley's Telegraph Works, Ordinary	10	6¾-7¼
House-to-House Company	5	1-1⅛
India Rubber and Gutta Percha Works	10	23¾-24¼
—— 4½ per cent. Debentures	100	103-106
International Okonite, Ordinary	10	1-2
Kensington and Knightsbridge	5	4¾-5¼
Liverpool Electric Supply, Ordinary	5	6¾-6⅞
—— Pref.	4½	5¾-6⅛
Liverpool Overhead Railway	10	8 3/16-8 5/16
—— Pref.	10	12¾-13¼
—— 4 per cent. Mortgage Debentures of £100	100	112-114
London Electric	5	¾-1⅛
Metropolitan Electric Supply	10	8¾-9
—— 5 per cent. Reg. Debentures, 1-10,000 in Bonds of £10, £20, and £40	—	108-111
National Telephone, Ordinary	5	4¾-5⅛
—— 6 per cent. Cum. First Pref.	10	15-16
—— 6 per cent. Cum. Second Pref.	10	14¾-15¼
—— 5 per cent. Nom. Cum. Third Pref.	5	5¼-5⅝
—— 4½ per cent. Deb. Stock	—	113-115
Notting Hill Company	10	4¾-5¼
Oriental and Electric Company, £1 shares	1	¾-1⅛
—— £5 Shares	—	5¾-6⅛
Southampton Electric Company	—	—
St. James's and Pall Mall, Ordinary	5	7-7½
—— 7 per cent. Pref.	5	8¾-9⅛
Swan United	8½	2-2⅜
Telegraph Construction and Maintenance	13	40-42
—— 5 per cent. Bonds	100	104-107
Westminster Electric Supply, Ordinary	5	8¼-8⅝
Yorkshire House-to-House	4½	4¼-4⅝

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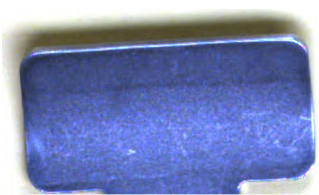

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